John McPhale, x440

AMERICAN SCIENCE AND ENGINEERING

20 MAY 1970

ASE-2432

11 CARLETON STREET, CAMBRIDGE,
MASSACHUSETTS 02142 (617) 868-160

FINAL REPORT FOR

PRIME DATA REDUCTION AND ANALYSIS OF THE AS&E OSO-IV POINTED AND WHEEL EXPERIMENTS

BY

R. GIACCONI
H. GURSKY
A. KRIEGER
S. NARANAN
F. PAOLINI
G. VAIANA
D. WEBB

CONTRACT NO. NAS 5-11106

PREPARED FOR

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

ASE-2432

FINAL REPORT FOR

CONTRACT NO. NAS5-11106

PRIME DATA REDUCTION AND ANALYSIS OF THE AS&E OSO-IV POINTED AND WHEEL EXPERIMENTS

Prepared by

R. Giacconi, H. Gursky, A. Krieger,
S. Naranan, F. Paolini, G. Vaiana, D. Webb

American Science & Engineering, Inc.
11 Carleton Street
Cambridge, Massachusetts 02142

Prepared for

National Aeronautics
and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

20 May 1970

Approved: Riccardo Giacconi
R. Giacconi
Executive Vice President

H. Gursky, Vice President
Space Research Division

G. S. Vaiana, Head
Solar Physics Group

FOREWORD

This document is the final report for Contract NAS5-11106 to perform the post-launch and prime data reduction and data analysis of the AS&E grazing incidence x-ray telescope experiment on the pointed section of the OSO-IV satellite, and the AS&E rotating wheel experiment. The contract covers the period 19 November 1967 to 30 April 1970. The spacecraft was launched on 18 October 1967 and the experiment has operated successfully throughout its lifetime. At the present time it continues to return useful information on the location of sources of solar x-ray activity, although there has been some loss of sensitivity.

The scientific objectives of the pointed x-ray telescope experiment are to study the structure of solar x-ray sources in several wavebands over an extended period, and to study the relationship of these sources to problems of solar physics. The objectives of the rotating wheel experiment are to locate sources of soft x-rays in the celestial sphere and to determine their intensities and spectral properties within several wavebands.

The reduction and analysis of the OSO-IV data has taken place in several phases. Prior to the launch of the spacecraft, computer programs for data reduction were developed and tested. This phase covered the period 30 June 1966 to 31 March 1967.

The work reported in this document covers the second and third phases. Post-launch data reduction commenced 19 November 1967, one month after the launch of the spacecraft, and continued until 30 June 1968. Preliminary data analysis commenced during this phase. The character and quality of the scientific results to be gained from the experiment were defined during this phase of the analysis and preliminary results were reported to the scientific community. The prime data reduction and analysis phase began 1 July 1968. During this phase, routine data reduction was completed for all data received in the form of computer readable experimental data and spacecraft attitude magnetic tapes (essentially the period from experiment turn on, 25 October 1967, to spacecraft tape recorder failure, 12 May 1968). This data has been examined, significant events have been selected, and the data for this period has been analyzed in detail. The results of these analyses have been reported to the scientific community as they became available.

The Principal Investigator on this contract was Dr. Riccardo Giacconi. The Project Scientist for the data reduction and analysis of the OSO-IV AS&E pointed x-ray experiment, covered in Sections 1.0 through 6.0 of this report, was Dr. Giuseppe S. Vaiana. The Project Scientist for the data reduction of the AS&E x-ray stellar rotating wheel experiment on OSO-IV (Section 7.0) was Dr. Herbert Gursky.

CONTENTS

ILLUSTRATIONS

Figure		Page
4-4	Corrected raster for 10 November 1967, 1908-1913 UT.	4-10
4-5	Corrected raster for 10 November 1967, 2105-2110 UT.	4-11
4-6	Corrected raster for 11 November 1967, 0006-0011 UT.	4-12
4-7	Corrected raster for 11 November 1967, 0202-0207 UT. Compare with Figure 4-1, the equivalent raw raster scan.	4-13
4-8	Corrected raster for 11 November 1967, 0448-0453 UT.	4-14
4-9	Time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9034 in late October 1967.	4-18
4-10	Time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9047 for three days in November 1967.	4-19
4-11	Time history trace of McMath plage region 9101.	4-20
4-12	Time history trace of McMath plage region 9108.	4-21
4-13	Time history trace of McMath plage region 9110.	4-22
4-14	Time history trace of McMath plage region 9115.	4-23
4-15	Time history trace of McMath plage region 9118.	4-24
4-16	Time history trace of McMath plage region 9146.	4-25
4-17	Time history trace of McMath plage region 9204.	4-27
4-18	Time history trace of McMath plage region 9222.	4-29
4-19	Time history trace of McMath plage region 9224.	4-30
4-20	Time history trace of McMath plage region 9225.	4-31
4-21	Time history trace of McMath plage region 9267.	4-32
4-22	Time history trace of McMath plage region 9273.	4-34
4-23	Time history trace of McMath plage region 9285.	4-35
4-24	Time history trace of McMath plage region 9313.	4-37
4-25	Time history trace of McMath plage region 9358.	4-39

1.0 INTRODUCTION

The grazing incidence x-ray telescope on the OSO-IV spacecraft obtained solar images in the 2.5 to 12 Å wavelength region, nearly continuously from 27 October 1967 to 12 May 1968. The spatial resolution of this instrument is on the order of one arc-minute. The time resolution can be as short as 5.12 minutes, but is usually 20.5 minutes.

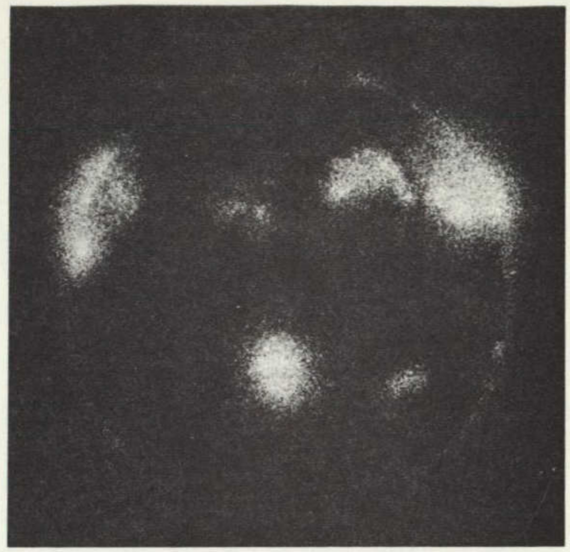
The instrument has sufficient spatial resolution to locate and identify the sources of the solar x-ray emission and to provide an estimate of the source size. The instrument can measure the x-ray emission from a particular region even while the majority of the solar x-ray flux is coming from other regions. Consequently, the x-ray telescope is able to observe time variations in the x-ray flux emitted by an individual active region and to follow the evolution of this activity for several solar rotations.

The body of this report is devoted to the results of the analysis of the OSO-IV data. This analysis was conducted concurrently with higher resolution rocket investigations as part of the AS&E Solar X-ray Astronomy Program.

1.1 AS&E Solar X-ray Astronomy Program

The AS&E program of x-ray observations of the quiet and active solar corona, which began ten years ago, has been directed towards the simultaneous acquisition of data with high spatial, spectral and temporal resolution by means of grazing incidence x-ray telescopes. During this period, the grazing incidence optics have evolved from the first crude versions to high precision telescopes such as the S-054 instrument to be flown on ATM (better than 2 arc-second resolution). Figure 1-1

15 MARCH 1965
(AS&E / GSFC)



20 MAY 1966
(GSFC)

8 JUNE 1968
(AS&E)

Hα
8 JUNE 1968
(COURTESY OF ESSA)

Figure 1-1 Three x-ray photographs of the sun showing the evolution in x-ray telescope performance over the past few years. Also shown is an Hα picture taken at the time of the 8 June 1968 rocket flight. The flare is the brightest feature close to the center of the disk (overexposed in this particular exposure).

illustrates the progress of x-ray imaging experiments during the last several years.

The OSO-IV experiment is part of a systematic study of the quiescent and active x-ray corona by rocket and satellite observations. The following list summarizes these observations:

First use of grazing incidence optics (Aerobee 150 flown in November 1963)

X-ray photography of the sun at solar minimum[1, 2] (Aerobee 150 flown in March 1965)

Long-term monitoring of x-ray emission by active regions with arc-minute resolution[3, 4, 5, 6] (OSO-IV satellite launched in October 1967 and still operating)

First attempt at flare x-ray photography (only partially successful because of pointing control failure) (Aerobee 150 flown in March 1968)

Observation of an x-ray flare with few arc-seconds resolution. First use of slitless spectrometer technique[7, 8, 9] (Aerobee 150 flown in June 1968)

Observation of quiescent coronal structures on the disk with few arc-seconds resolution and limb observations to more than 0.3 solar radii in height (Aerobee 150 flown in April 1969)

Flare x-ray cinematography to observe the spatial development of an x-ray flare and to associate the microwave and hard x-ray bursts with centers of emission inside the flare region (Aerobee 150 flown in November 1969)

Observation of the x-ray corona near the time of a solar eclipse to unambiguously associate large radius eclipse observations with disk features. Observation of the lunar de-occultation of an active region to determine the altitude dependence of the x-ray emission with greater precision. (Aerobee 150 flown in March 1970)

With the exception of the AS&E grazing incidence telescope experiment on OSO-IV, described in this paper, all of these observations were made from sounding rockets. Rocket flights have a typical duration of less than five minutes. Thus, rocket-borne detectors cannot observe the time variations in the behavior of x-ray active regions. In order to observe the time behavior of the x-ray activity of individual emitting regions, a satellite-borne instrument is required with sufficient spatial resolution to distinguish and locate the emitting regions.

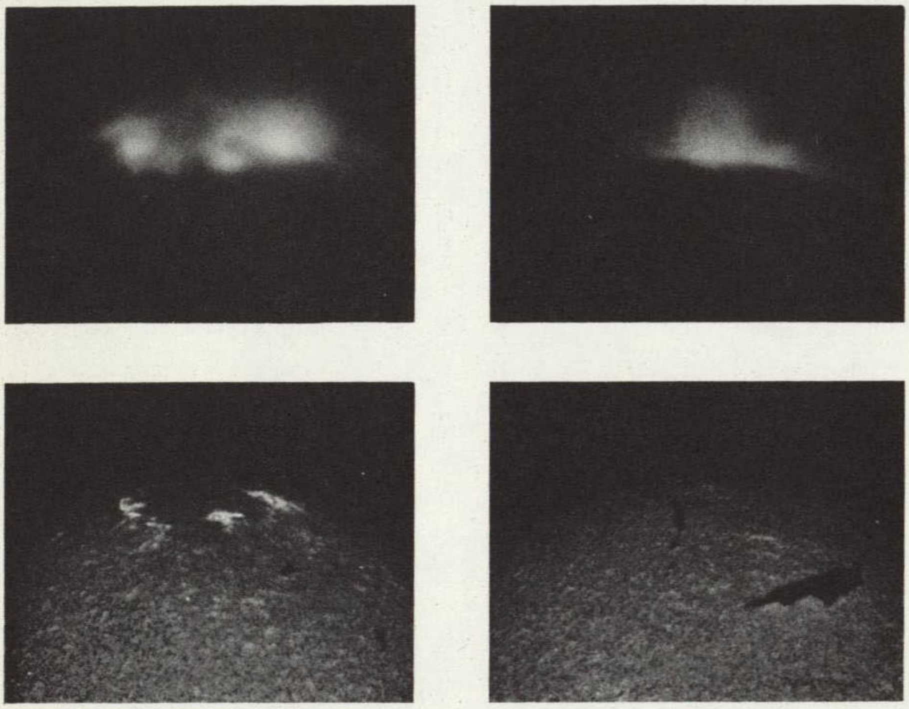
This long-term monitoring with moderate spatial resolution is the unique characteristic of the x-ray telescope experiment on OSO-IV. The still photographs from recent rocket flights, however, show details of x-ray emitting regions with a spatial resolution orders of magnitude better than available with the OSO-IV experiment. Therefore, in order to relate the results of the OSO-IV analysis to the higher resolution photographs, it is appropriate to summarize some of our rocket results.

Our three most recent rocket flights have revealed the existence, within x-ray emitting regions, of structures [8, 9] with dimensions on the order of a few arc-seconds. The structure of an emitting region may closely resemble that of the corresponding Hα plage (Figure 1-1 and 1-2) when seen on the disk.

Examination of the spatial distribution of the x-ray and Hα emission near the limb (Figure 1-3) shows that the x-ray emission extends to considerable heights (100, 000 to 150, 000 km) in the corona above the active region. This three-dimensional structure may take the form of loops connecting portions of the same active region or of nearby active regions. The configuration of the x-ray emitting plasma appears to be governed by the magnetic field.

DZ-065

Figure 1-2 An x-ray exposure of the sun taken 8 June 1968 at 1745 UT while an importance 1n flare was in progress. The exposure was made with the AS&E 34 cm^2 x-ray telescope.



DZ-072

Figure 1-3 Comparison between x-ray and Hα emission shows the three dimensional structure of active regions. Three loops can be seen to connect active regions in the left set.

The structure is quite complex and does not correspond to a simple bi-polar field configuration within one active region.

The x-radiation of the flare of 8 June 1968 derives neither from a single bright point, nor from a diffuse blob of unconfined plasma. Instead there is a general correspondence between the regions of x-ray and Hα emission. (A detailed comparison of the spatial distribution in Hα and x-rays is shown in Figure 1-4.) A significant exception to this is seen where part of the brightest x-ray emission bridges a dark lane between two Hα emission centers located on opposite sides of the zero longitudinal field line. Roughly 50% of the total x-ray emission of the flare comes from a region of about 15 arc-seconds dimension about this point. Figure 1-5 presents a comparison between the photospheric magnetic structure, the x-ray structure and the Hα structure. The three rectangles correspond to the same portion of the flare region and are at the same scale. We note the coincidence between the bright x-ray emission and the regions of higher longitudinal field gradient.

Exposures taken in the slitless spectrometer configuration have provided spectra from 3 to 15° of individual active regions. The spectra obtained confirm the marked difference between the flare region and other active regions (Figure 1-6). The spectrum of the flare region is substantially harder than that of the active region, as expected. Significant differences, however, are also present between the spectra of non-flaring active regions.

On the rocket flight of 8 April 1969, the structure of the x-ray emitting regions of the general corona was observed on the disk for the first time (Figure 1-7). In addition to the bright limb, familiar from earlier x-ray photographs, the disk is seen

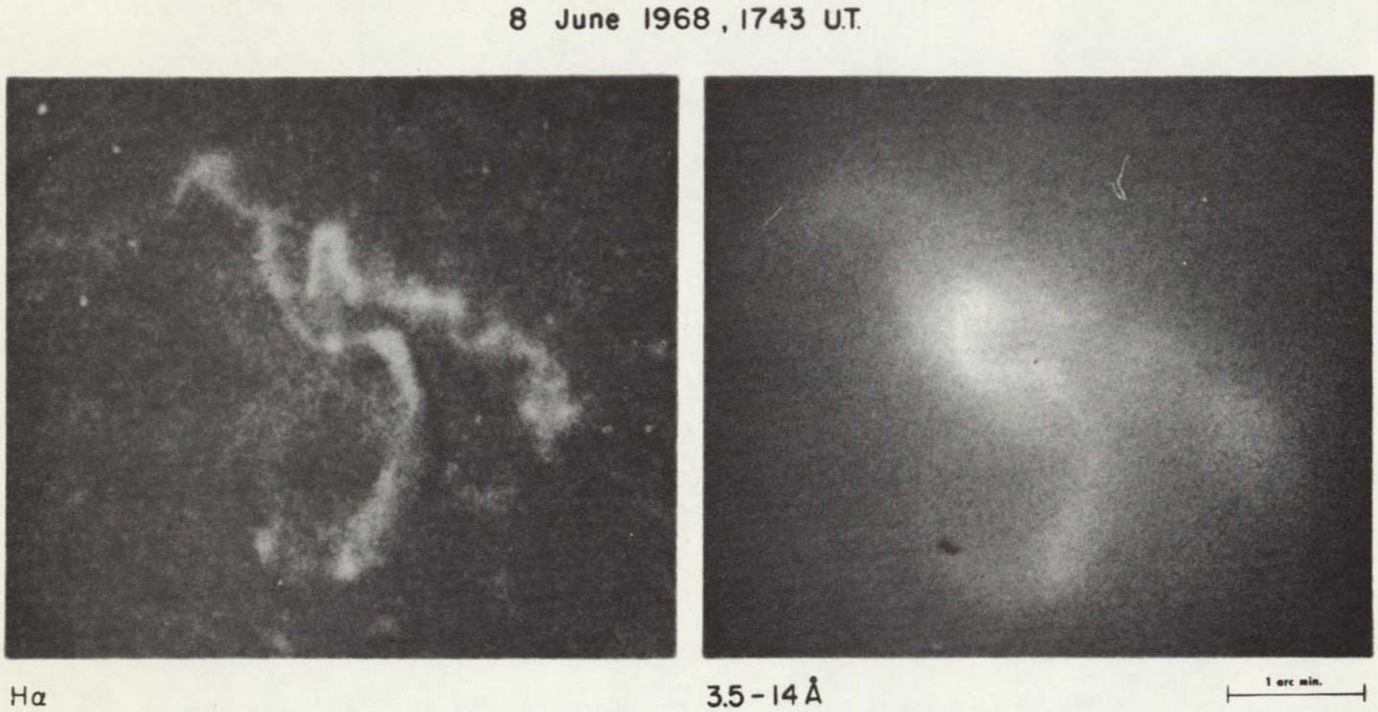


Figure 1-4 Comparison of the flare region in Hα and x-rays.

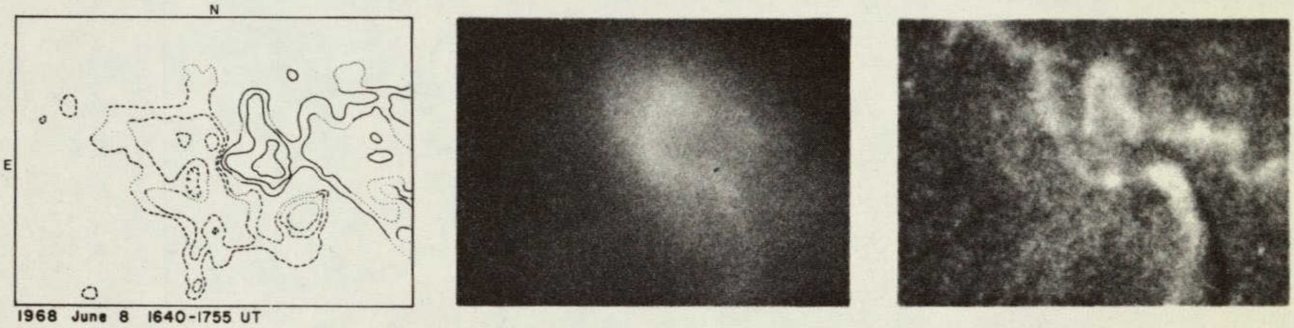


Figure 1-5 Comparison of the flare in magnetic field, x-rays, and in $H\alpha$.

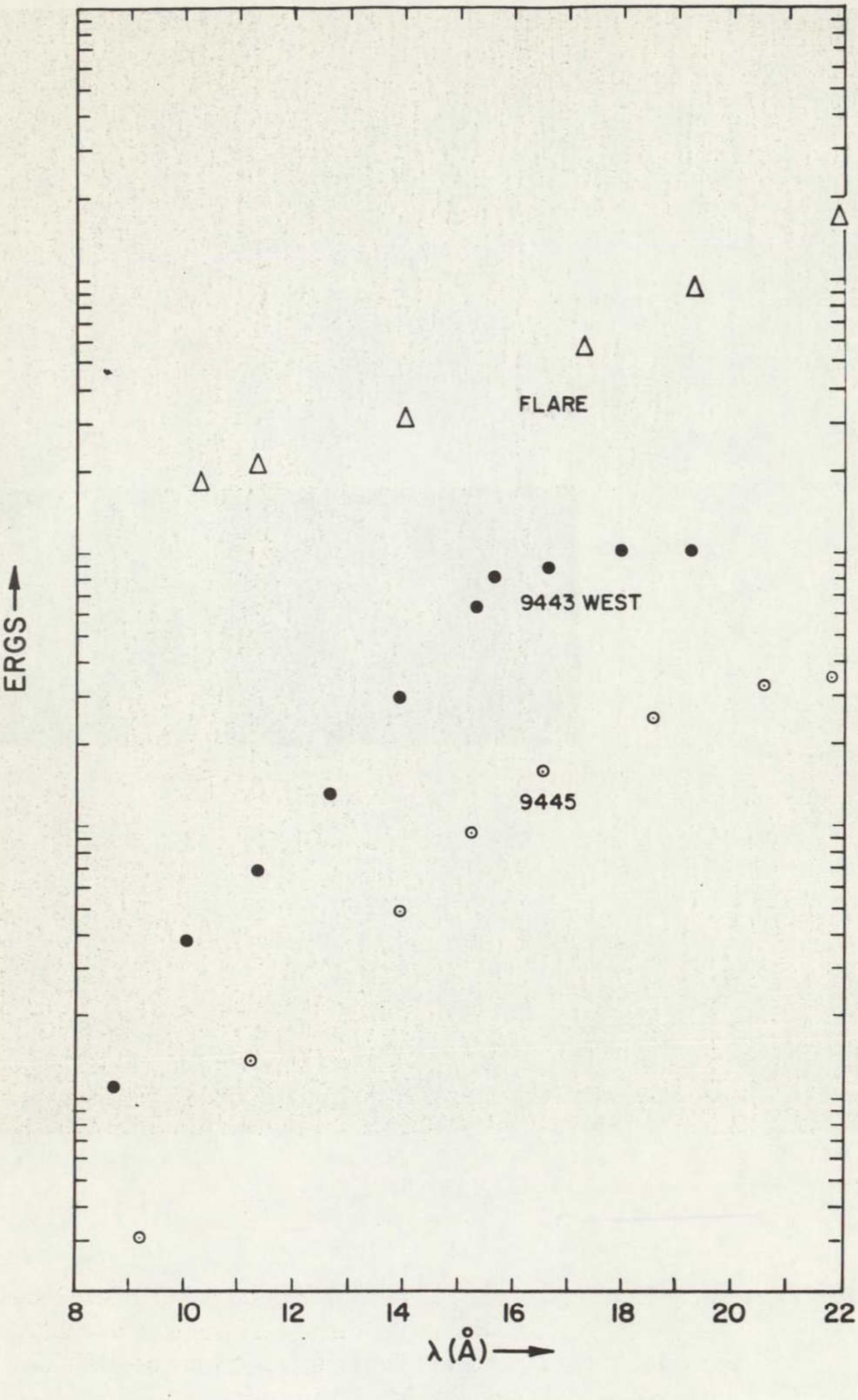
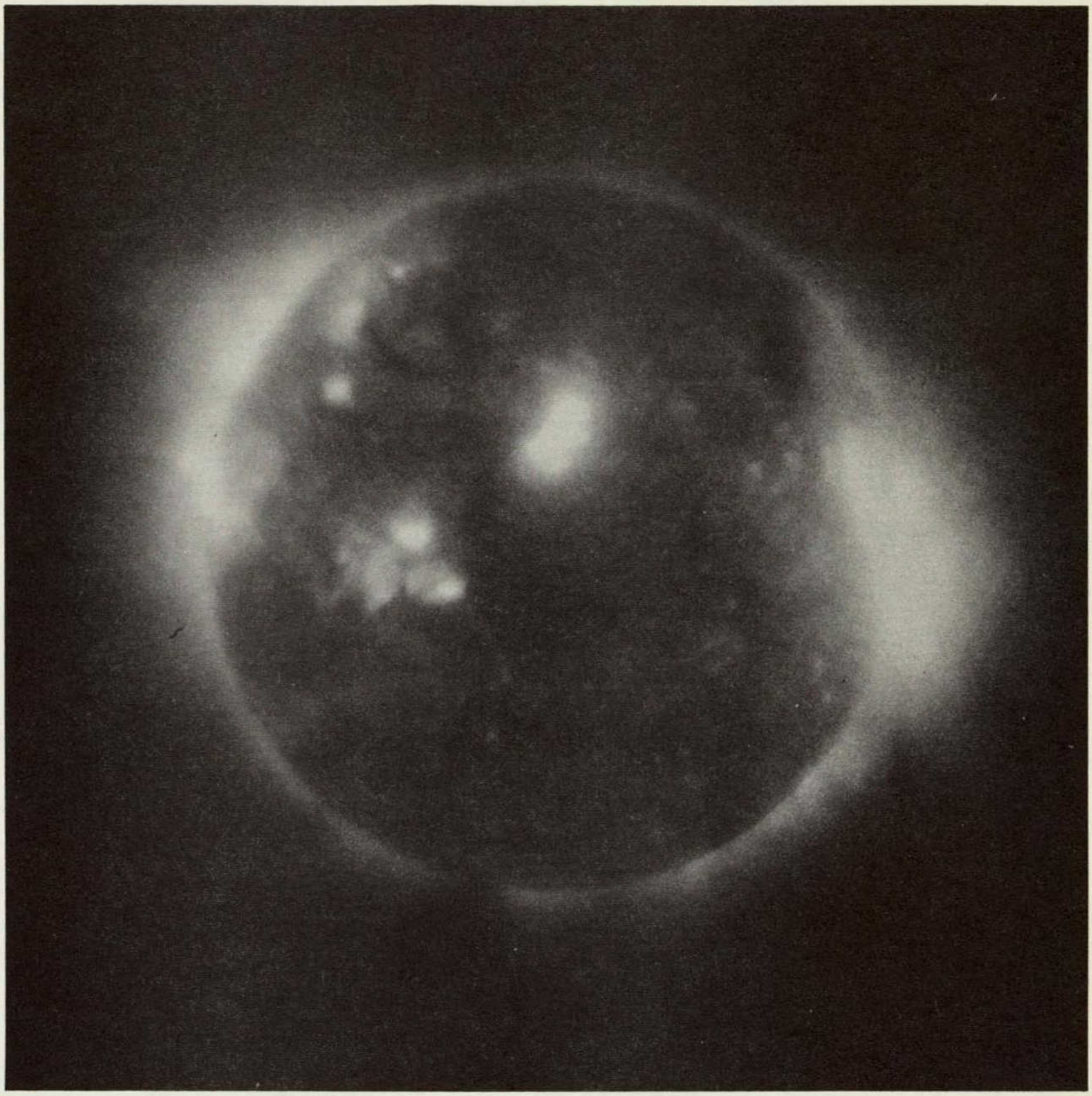


Figure 1.6 Spectra obtained by the slitless spectrometer in the 8 June 1968 rocket flight. The flare spectrum is substantially harder than either of the other two active regions shown. The spectrum of region 9445 is significantly harder than of region 9443. The ordinate is left blank pending absolute energy calibrations.



EF-011

Figure 1-7 An x-ray exposure of the sun taken 8 April 1969 by AS&E's 34 cm^2, rocket-borne, x-ray telescope. In addition to the active regions and bright limb, both point-like and diffuse structures appear on the disk.

to display inhomogeneous structure. Small, concentrated, point-like features and more diffuse structures are both noticeable. A preliminary examination indicates that the latter structures are more diffuse than the chromospheric structure evident in CaK spectroheliograms. The point-like structures correspond to particularly bright features of the chromospheric network with bi-polar fields. The nature of these inhomogeneities in the low corona is not yet clear. The relationship between these structures and the magnetic sector structure and longitudinal velocity structure of the solar wind requires further investigation.

1.2 Scientific Objectives

The scientific objectives of the post-launch and prime data analysis phases of the OSO-IV pointed experiment were to analyze and interpret the data obtained from the OSO-IV x-ray telescope experiment. In particular, (1) to use the spatial resolution of the instrument to distinguish individual active regions in order to study their location and size during both flaring and quiescent periods; (2) to use the extended duration of the experiment to study the temporal behavior of the x-ray flux from active regions; and (3) to investigate the relationship between the soft x-ray emission of active regions and their manifestations at other wavelengths (e.g., $H\alpha$ and microwave radio emission). The specific tasks to be performed encompass four areas: routine data reduction, x-ray plage analysis, x-ray flare analysis, and scientific collaboration with other experimenters.

1.2.1 Routine Data Reduction

Upon receipt of GSFC supplied experiment data on magnetic tape, AS&E reduced, computed and printed out the data in raster format. Duplicate tapes were submitted to NSSDC as required.

1.2.2 X-ray Plage Analysis

Computations were performed to arrive at spectral hardness indices, temperature, and electron densities over selected active plages. Correlation analysis was conducted of plage x-ray brightness with temperature, magnetic field intensities and gradients, Hα and other related solar parameters. The plage evolution was studied, and the findings were interpreted using specific plage models.

1.2.3 X-ray Flare Analysis

Graphs were constructed of x-ray flare brightness and x-ray flare hardness index as functions of time. Computations were made of peak irradiance of flares summed over the entire plage subfield, of x-ray flare equivalent temperature and of total energy output of flares. Correlation analysis was performed of x-ray flare brightness and Hα peak brightness, flare sizes and Hα sizes, flare brightness, and other flare parameters. Results were interpreted using specific flare models, and an attempt to improve flare forecasting was made.

1.2.4 Scientific Collaboration

AS&E has established collaborative relationships with other OSO-IV experimenters and experimenters of other spacecrafts. During the period of performance of this contract, AS&E met and exchanged information with these individual scientists and with interested government agencies. The contractor made available the data and findings, at the discretion of the NASA technical monitor, by publishing it in technical journals and presenting it at technical meetings.

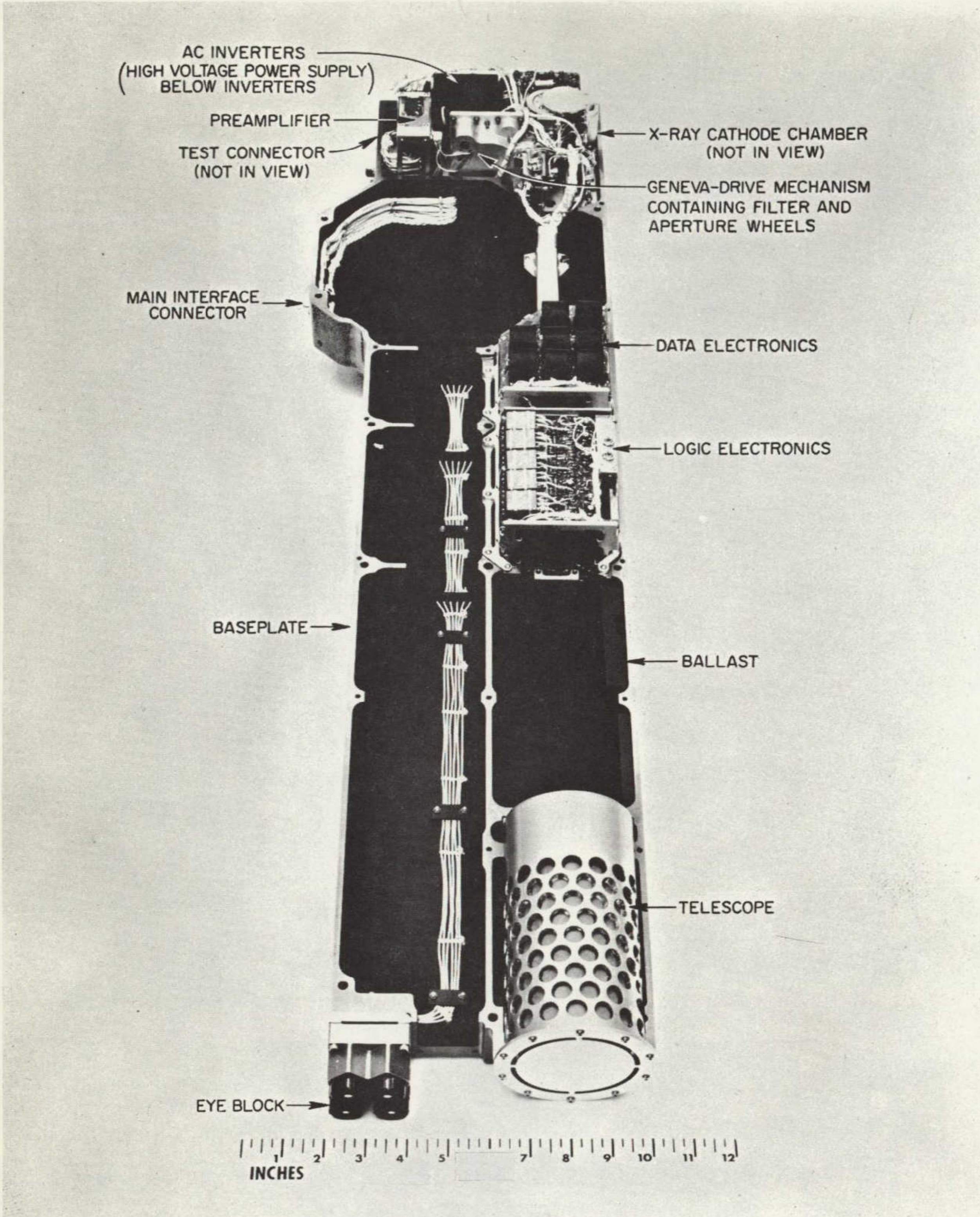
2.0 DESCRIPTION OF EXPERIMENT

2.1 Instrumentation

The grazing incidence x-ray telescope is a two-mirror, image forming system of optics. Incident x-rays reflect off the first mirror, which is a paraboloid of revolution, onto the second mirror, which is a confocal hyperboloid of revolution. The radiation reflected off the second mirror subsequently forms a true image of the source in the focal plane of the system. For x-radiation of wavelengths greater than 2 Å, angles of incidence are less than the critical angle necessary for total external reflection; reflection efficiency is therefore high. A detailed description of grazing incidence x-ray telescope design and application has been given by Giacconi et al.[10]

The telescope on OSO-IV (shown mounted into the instrument in Figure 2-1) is fabricated of electroformed nickel; it is approximately 7.6 cm in diameter by 16 cm long; its collecting area is 2.01 cm^2; and its focal length is 83.6 cm. Its inherent resolution is 20 arc-seconds. The grazing angle of reflection for rays incident parallel to the axis is 40 arc-minutes for both reflections.

The reflection efficiency of the x-ray telescope was measured at the 8.3 Å aluminum line. The reflection efficiency on axis was found to be 28%. The theoretical reflection efficiency[11] at 8.3 Å for two reflections from nickel surfaces pitched at equivalent angles to the x-ray beam (that is, 40 arc-minutes for both reflections) is approximately 65%. This difference between the theoretical and actual efficiencies is considered typical of x-ray telescopes fabricated by the electroforming technique. The theoretical and measured reflection efficiencies



CD - 123A

Figure 2-1 ASE Pointed X-ray Telescope.

are shown in Figure 2-2.

Transmission as a function of wavelength for all filters was calculated from the values of the mass absorption coefficients tabulated by Henke et al.[12] and measured areal densities ($gm\text{-}cm^{-2}$) of the filter materials used. Their transmissions to 8.3 Å Al-Kα x-radiation were then experimentally measured and were found to be consistent with calculations. Besides the wheel-mounted filters, there is a fixed filter in the optical path of 0.00015 inch Mylar with 2000 Å evaporated Al, adding primarily 0.53 mg/cm^2 of C.

The detector is a "photoemission-scintillation" detector. Lincke and Wilkerson[13] have described its use in the extreme ultraviolet. The detector (Figure 2-3) consists of an external photocathode and a scintillation detector. The photocathode is a conical shell of nickel substrate, the interior of which is coated with CsI. This substance has been found, by Lukirskii et al.[14] to have an extremely high photoelectric quantum efficiency for x-radiation. The photocathode is held at a potential of -10 kV. The scintillation detector uses a plastic scintillator mounted on a lucite light pipe, and viewed by a 14-stage photomultiplier. The scintillator is coated with a film of vacuum-deposited aluminum; the aluminum film is at ground potential.

Incident x-radiation strikes the interior of the conical cathode and causes, with high probability, the emission of one or more photoelectrons. The conical shape of the photocathode substrate structure and the planar shape of the aluminum filter over the scintillator form an electrostatic lens which directs the photoelectrons into the scintillator. This produces enough

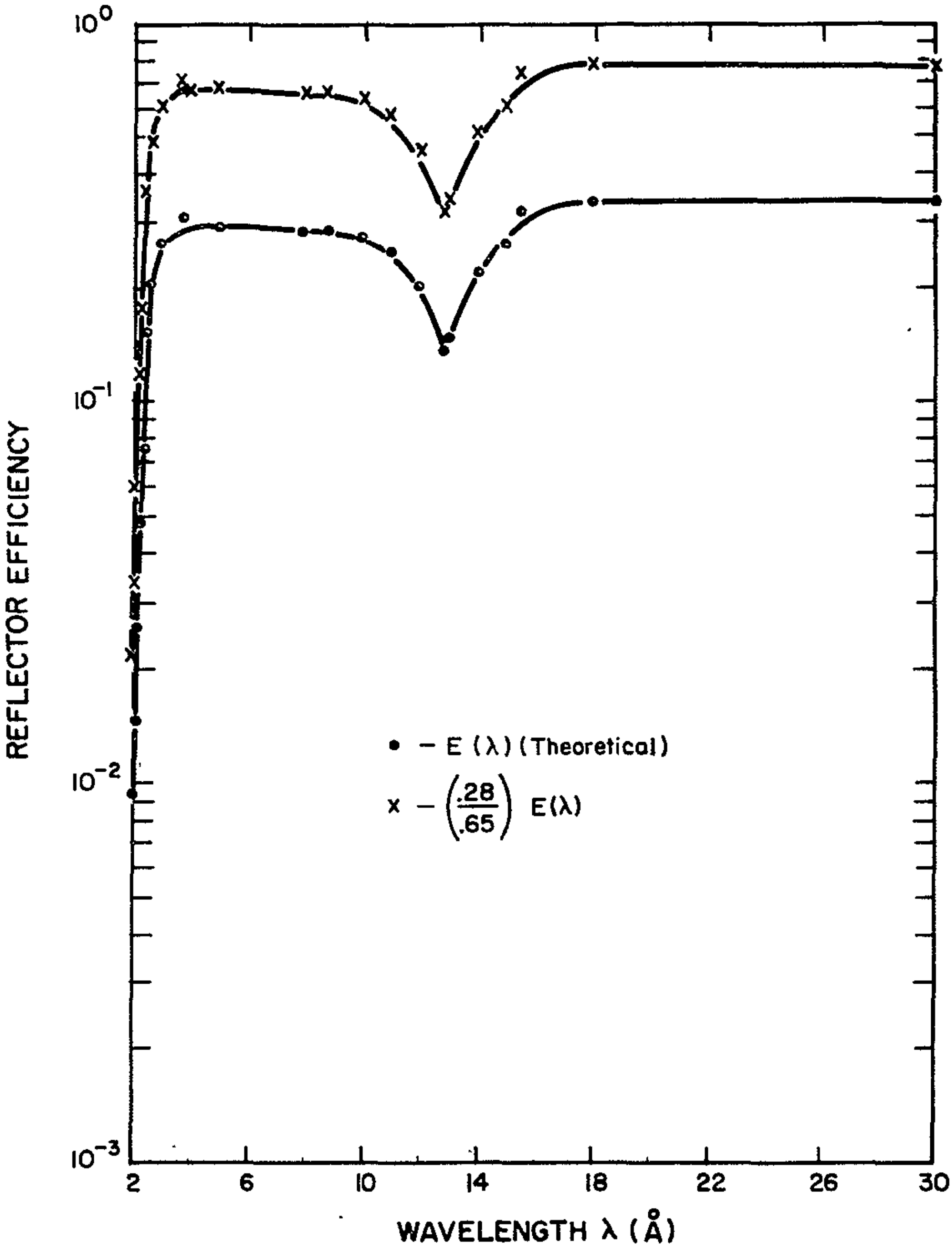


Figure 2-2. Theoretical and measured reflection efficiencies (telescope).

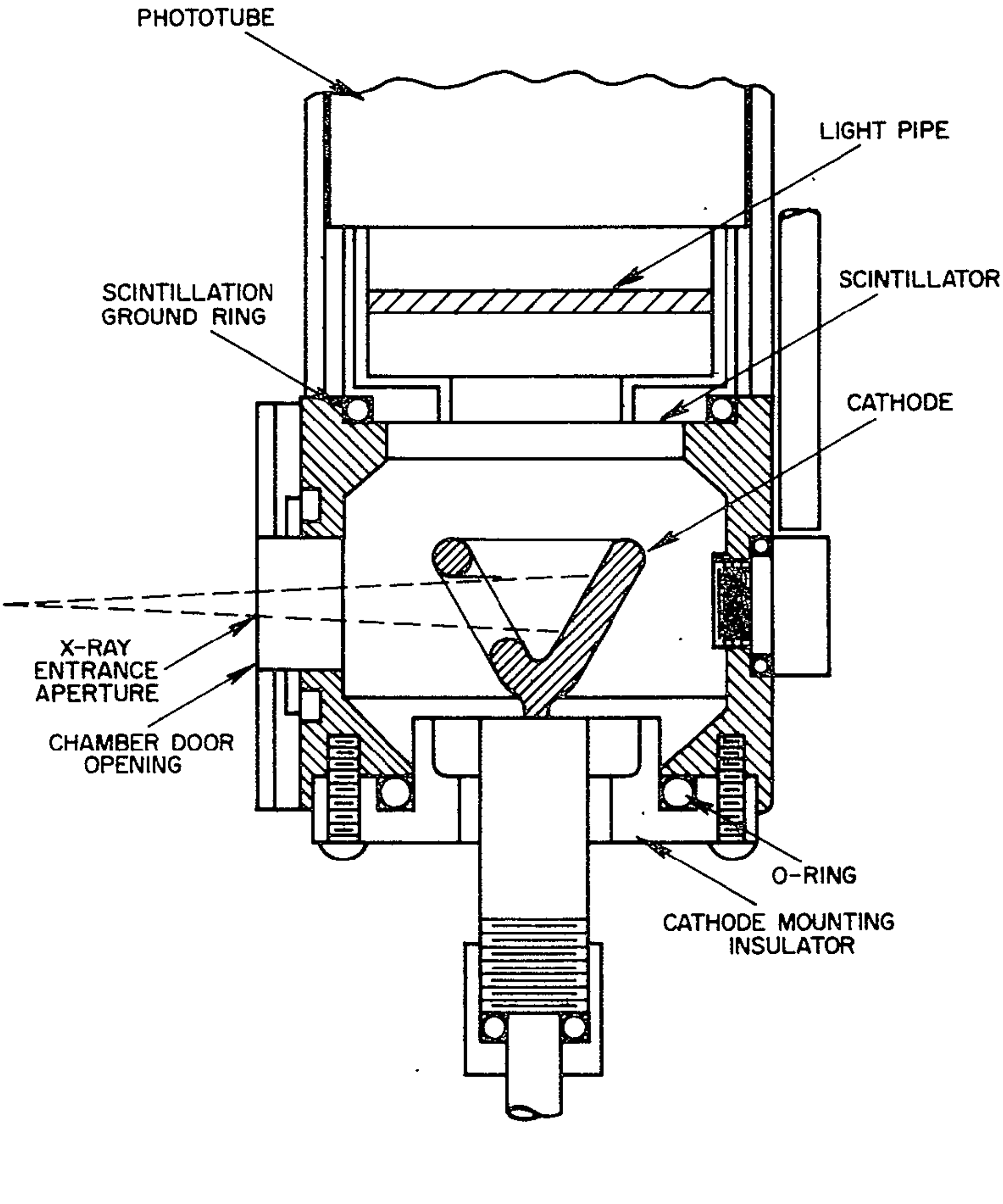


Figure 2-3. Photocathode detector chamber.

scintillation light to be detected by the photomultiplier with reasonable efficiency.

2.2 Experimental Procedure

2.2.1 X-ray Telescope

A schematic representation of the AS&E grazing incidence x-ray telescope experiment is shown in Figure 2-4. The instrument uses a grazing incidence system of mirrors (an x-ray telescope) which form a true x-ray image of the sun on the Aperture Wheel in the focal plane of the telescope. The wheel contains four apertures of two different sizes (one arc-minute and four arc-minutes) which determine the spatial resolution of the optical system. The Aperture Wheel was programmed to step automatically between complete scans of the sun, or to stay at any desired position. As the OSO-IV pointed section scans the sun, its image moves over the Aperture Wheel. Only x-radiation from that region of the sun at which the instrument is pointed passes through the aperture for further analysis.

2.2.2 X-ray Detector Package

The x-radiation from a single picture element subsequently passes through one of three filters in the Filter Wheel located immediately behind the Aperture Wheel. The filters, together with a fixed filter in the optical path of the x-ray telescope and the reflection properties of the telescope itself, permit analysis of x-radiation in three wavelength bands. These are approximately: (a) 2.5 to 12 Å, (b) 2.5 to 11 Å, and (c) 2.5 to 9 Å. The Filter Wheel can be programmed to step automatically between complete scans of the sun. It cycles through four positions: three filter positions and a calibration position. It can also be programmed to stay at any desired fixed position.

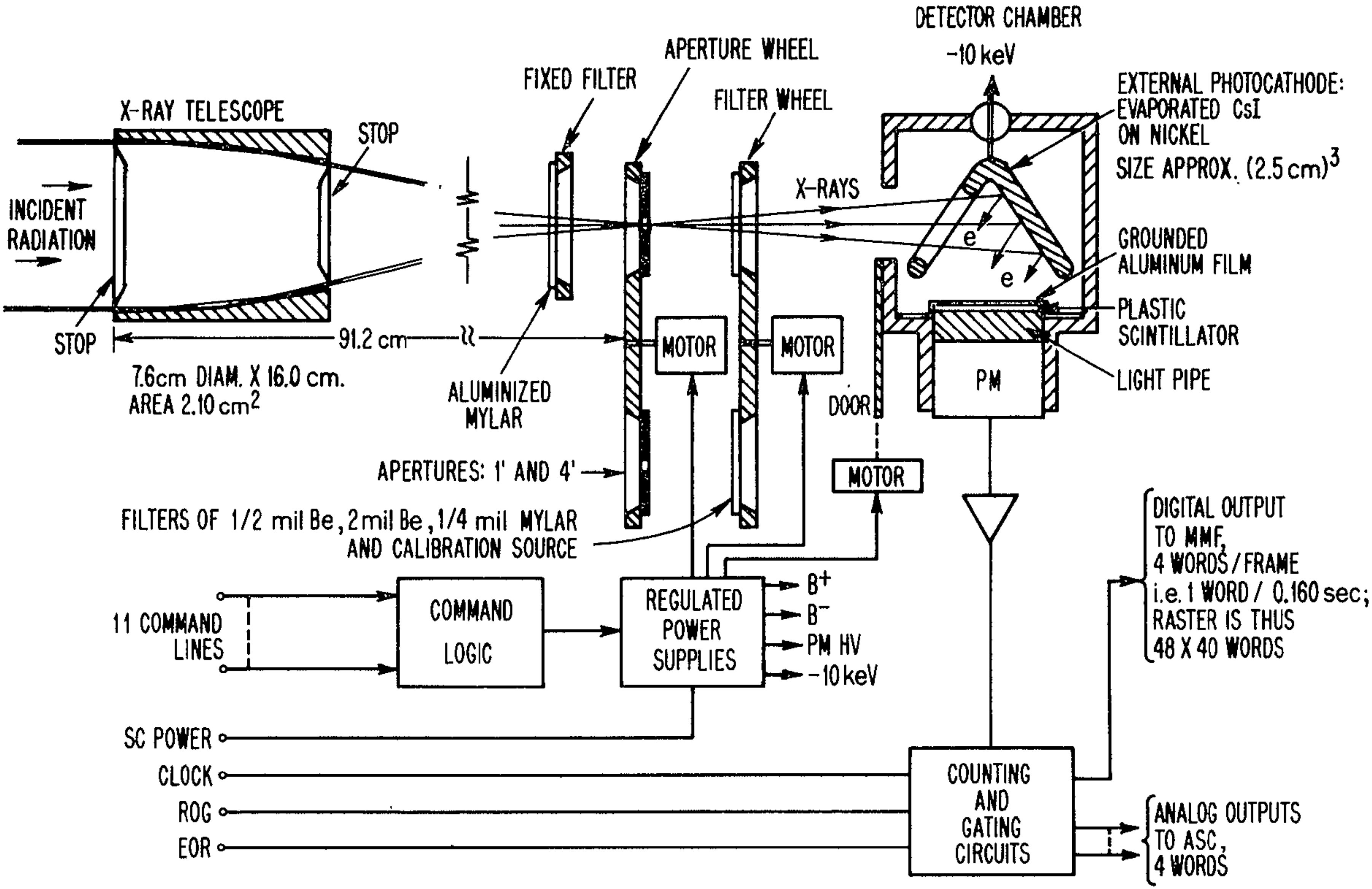


Figure 2-4. AS&E x-ray experiment on the OSO-IV pointed section.

Beyond the filters, transmitted x-ray quanta strike the photocathode where photoelectrons are emitted and are then accelerated into the scintillator viewed by a photomultiplier tube. The counts accumulated between data sample times are thus proportional to the number of x-rays emitted from the corresponding picture element of the sun. A total of 1920 such sets of accumulated counts comprise the data from one complete scan of the sun.

2.2.3 Data Transmission

The pulses from the photomultiplier are subsequently counted and the result telemetered to the ground. These sets may be reconstructed on the ground into an array of 48 by 40 numbers which constitute an x-ray map of the sun. The position of a given number in the array corresponds to a unique position on the sun and the magnitude of the number corresponds to its brightness in x-radiation. Data accumulation time between these numbers is 0.14 seconds. Due to readout delay time, the actual time interval required to accumulate the data for one x-ray filtergram is 5.12 minutes. Thus, if the Filter Wheel is cycling (as is usually the case), 20.5 minutes elapses between consecutive filtergrams through the same filter. Table I lists the instrumental characteristics of the OSO-IV telescope experiment.

TABLE I

OSO-IV INSTRUMENTAL CHARACTERISTICS

SPECTRAL RANGE:	2.5 - 12 Å	(2.65 μgm/cm^2 Beryllium filter)
	2.5 - 11 Å	(1.4 μgm/cm^2 Mylar filter)
	2.5 - 9 Å	(9.4 μgm/cm^2 Beryllium filter)
SPATIAL RESOLUTION:	1 arc-minute	
	4 arc-minute	
TIME RESOLUTION:	5.12 minutes	
	20.48 minutes	
MINIMUM SENSITIVITY:	1.4×10^4 photons/cm^2-sec	
	3.5×10^{-5} ergs/cm^2-sec ($10^{7\circ}$K)	

3.0 CALIBRATION PROCEDURES

3.1 Ground Processing of Telemetry Information

The initial output "raw raster" consists of solar x-rays, background counts that are due to spacecraft generated noise (a function of raster position), and energetic charged particle counts. The latter counts depend upon spacecraft orbital position and time, but are independent of raster position. To determine the number of true counts due to solar x-rays, $\overline{N}$, as a function of raster position, one must subtract from the raw raster an "average background raster," which contains the spacecraft generated noise and the average charged particle counting rate.

The average background raster is generated from raster scans utilizing the Fe^{55} calibration source, instead of the x-ray filters, in the optical path of the telescope. Rasters obtained when the spacecraft was passing through the South Atlantic Anomaly are removed entirely from data processing.

The number of true counts, $\overline{N}$, accumulated during the 0.14 second live time interval between data words is related to the spectral distribution function, ϕ, at the spacecraft by the expression:

$$N\,(a,\ b,\ t,\ T) = 0.14\ A\int F\,(b,\lambda)\ \phi\,(a,\ t,\ T,\lambda)\ d\lambda \qquad (3.1)$$

where a = Aperture Wheel index, indicating the angular resolution mode of the experiment;

b = Filter Wheel index, indicating the transmission filter in position, and thus specifying an effective wavelength passband;

t = time;

T = spectral parameter indicating the nature of the source spectrum;

A = sensitive collection area of the telescope aperture;

λ = independent variable, wavelength, in Å;

ϕ = spectral distribution function of radiation at the spacecraft (units are photons/cm^2-sec-Å); and

F = instrument detection efficiency function.

The function of $F(b, \lambda)$ is expressed by

$$F(b, \lambda) = r(\lambda)\,\varepsilon(t)\,q(\lambda)\,x(b, \lambda) \qquad (3.2)$$

where r = telescope reflectance;

ε = scalar part of the photocathode detection efficiency, calculated from the in-flight calibration mode;

q = photocathode quantum efficiency indicating the probability that at least one photoelectron will be emitted upon irradiation by a single photon of wavelength λ; and

x = filter transmission function.

The functions $F(b, \lambda)$ for the three filters used in this experiment appear in Figure 3-1. A more detailed discussion of these relations is available elsewhere.[15]

3.2 Determination of the Calibration Counting Rate

The average background raster is constructed in the following manner. The constant, $\overline{N}_{cal}$, is the average counting rate due to the Fe^{55} calibration source, and is proportional to the x-ray detector efficiency. The quantity $\overline{N}_{40\ sun}$ is generated by averaging the counting rate of 40 raw raster positions, where the effect of solar x-rays and spacecraft generated noise are minimized. In practice these positions are usually the top 20 and bottom 20 lines in the first half of a raster. 80 lines per raster were used for data from later in the spacecraft's lifetime, to improve statistical precision due to falloff of the experiment detector efficiency. The least sensitive mode of

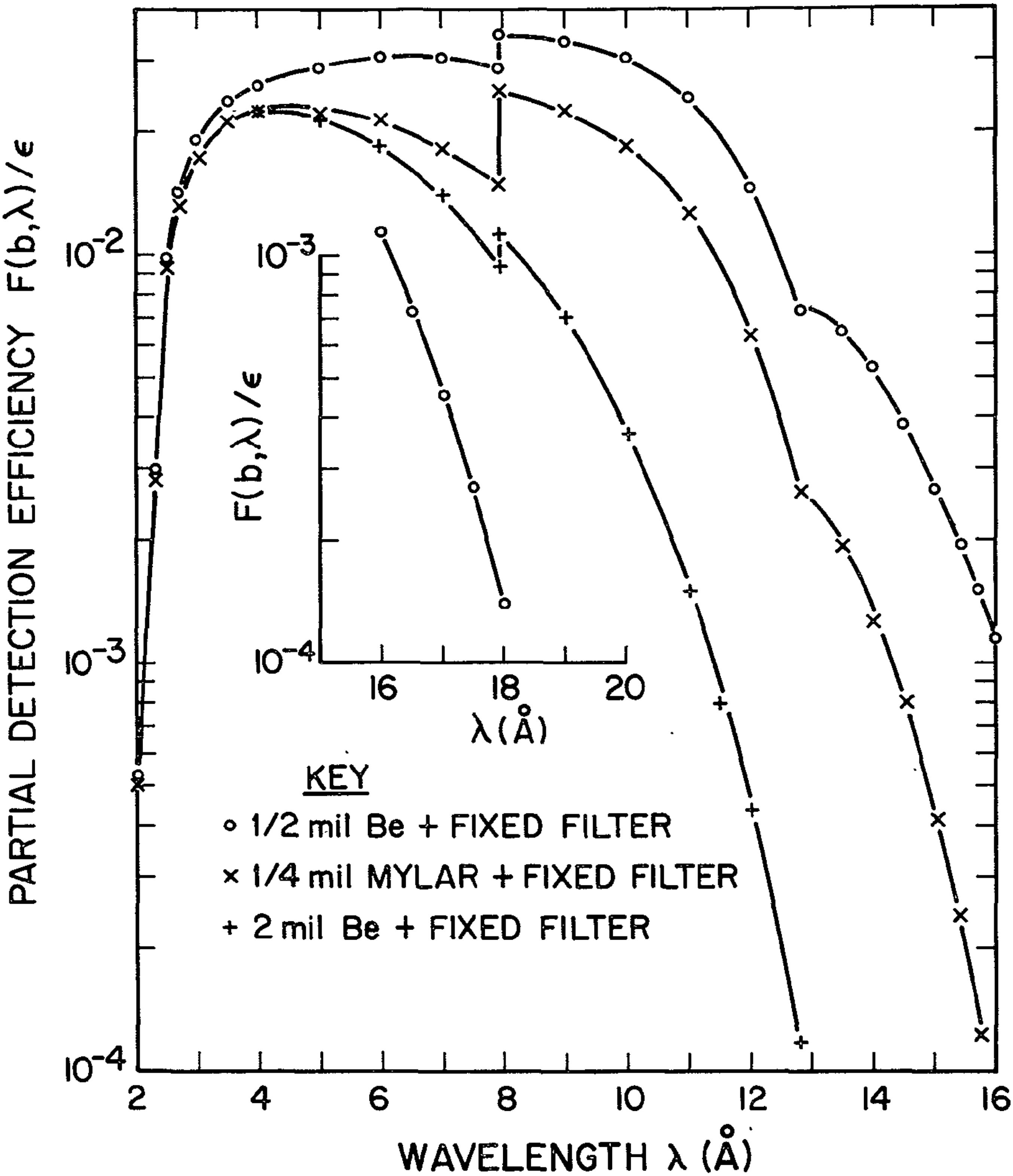


Figure 3-1. Instrument detection efficiency function for the three filters used in the experiment.

the experiment is used. The quantity $\overline{N}_{40\ cal}$ is generated by averaging the counting rate in the corresponding 40 positions of the calibration rasters taken during the same time period. $\overline{N}_{cal}$ is then calculated by subtraction of $\overline{N}_{40\ sun}$ from the corresponding $\overline{N}_{40\ cal}$.

$\overline{N}_{cal}$ can now be subtracted point by point over the entire "average calibration raster," obtained by summation of all calibration rasters during the specified time interval. The average background raster for this interval is thus produced. An x-ray filtergram of the sun, containing only solar x-rays, is then obtained by point by point subtraction of the appropriate average background raster from the raw raster.

Time variation in the sensitivity of the detector is monitored in the calibration mode. Figure 3-2 shows the time variation of the detector sensitivity for the first six months of the satellite's lifetime. The detector sensitivity $\overline{N}_{cal}$ has been corrected for the natural decay of the Fe^{55} source, whose mean life is 3.90 years, and normalized to its value on 27 October 1967, the starting date of routine solar scanning. It is apparent from the graph that a one-third reduction of the value of $\overline{N}_{cal}$ occurred during the first few weeks of operation. The exact cause of this decay is unknown, but probably is associated with deterioration and/or coating of the CsI photocathode surface. The sensitivity then decreased more slowly thereafter. The sensitivity remained high enough to allow monitoring of the x-ray flux of active regions throughout the period of this report.

3.3 Further Corrections to the True Counting Rate

3.3.1 Methods of Approximation

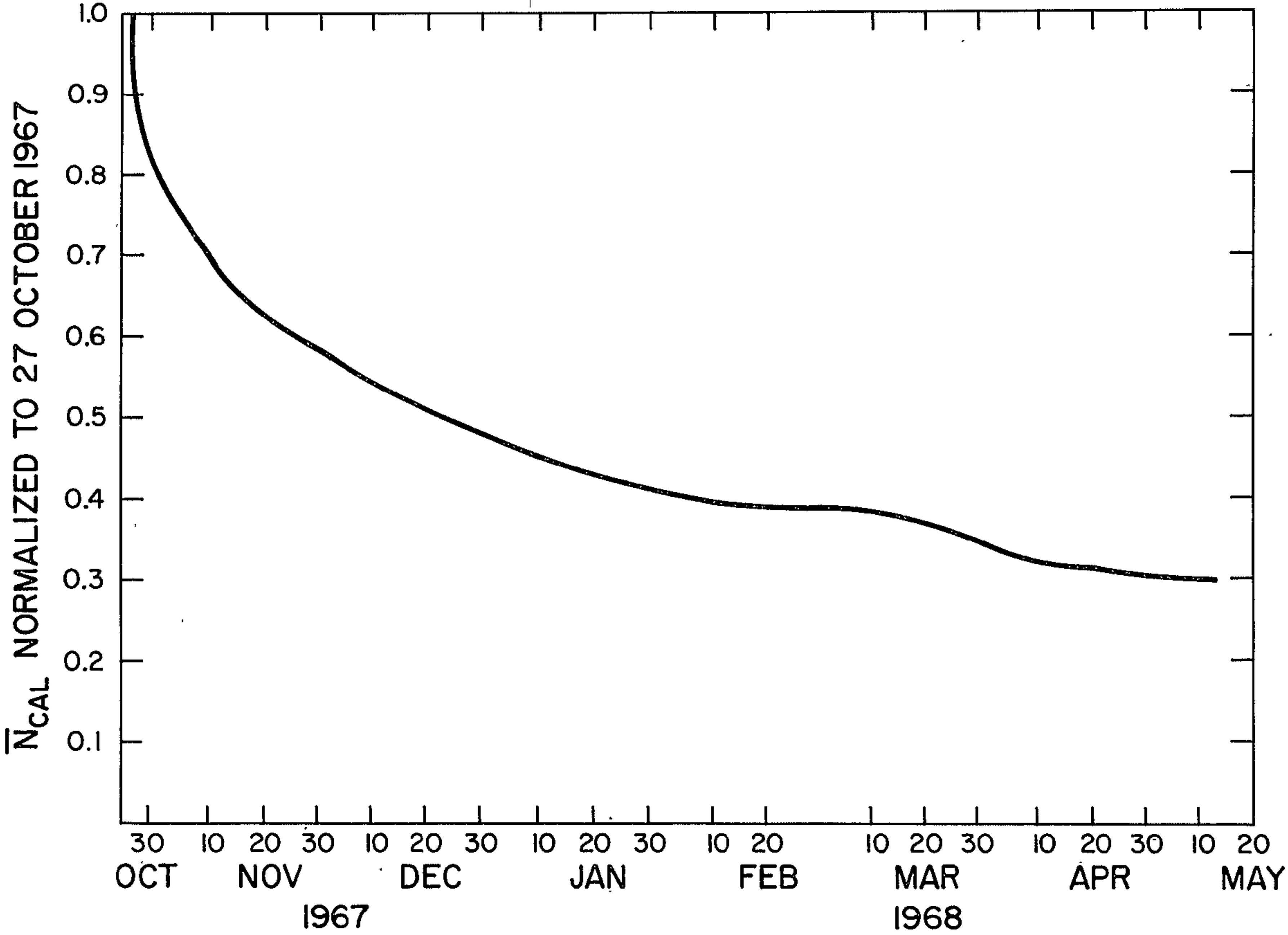


Figure 3-2. Time history of the relative x-ray sensitivity of the instrument, $\overline{N}_{cal}$, normalized to 27 October 1967.

The true counting rate per data word on the reduced x-ray filtergram must now be corrected for the time variation in detector sensitivity shown in Figure 3-2. From such a graph a daily multiplicative factor is computed that is simply the normalized rate of $\overline{N}_{cal}$ on any day to the value on 27 October 1967. It should be emphasized that all such corrections are relative to the initial in-flight conditions of the spacecraft.

To derive information on the total flux of an x-ray emitting region on a filtergram, ring integrals are formed about the center of the region as described in Section 4.4. For ease of computation and to avoid overlapping active regions, it is convenient to truncate the integrals at arbitrary radii from the center of the emitting region. Thus it is necessary to determine correction factors for the one and 4 arc-minute aperture stops to estimate the remaining flux in the uncounted rings.

Anticipating a result from Section 5.2.3, we find by comparing the observed x-ray intensity distributions of flares with the telescope response function that the flare brightness distributions are on the order of one arc-minute or less. Because our smallest telescope aperture diameter is one arc-minute, we make the assumption that the brightness distribution of flares represents the point source scattering function of our instrument. We chose the brightest x-ray flare, uncontaminated by adjacent regions, that occurred during the period covered in this report for determination of this "point source correction." This flare occurred at about 2200 UT on 16 November 1967. We calculated ring integrals for rasters near the flare's peak intensity in our two aperture modes. A table was produced listing the percentage of the total flux contributed by each ring. Thus to make the correction, the flux calculated out to a specified ring is divided by that ring's contribution factor to derive the total estimated flux.

This method is also applicable to any emitting region observed on rasters obtained with the 4 arc-minute resolution mode, since the majority of the flux from such regions is emitted from areas smaller than 4 arc-minutes.

3.3.2 Absolute Flux Calibration

In order to convert our measured counting rates to an absolute flux scale, we have compared our measurements for selected x-ray events with those of other experiments. One of the most useful comparisons was with data obtained by the University of Iowa detector on board Explorer 33, which operates in the same approximate waveband as our detector. We have used these calibrations to calculate representative flux values for x-ray emitting regions on time scales of interest. Some of these data appear elsewhere in this report.

4.0 COMPUTER REDUCTION AND ANALYSIS ROUTINES

4.1 General

The data analysis and reduction routines for the OSO-IV pointed x-ray telescope experiment are utilized on AS&E's in-house IBM system 360/40 Data Processing Facility. The program formats are mostly written in PL/I language and may be read from PL/I, assembly language, or COBOL. A few short, older programs are written in FORTRAN IV. Listings of the important data reduction programs are presented in the Appendix.

Data reduction commences at AS&E when compatible magnetic data and spacecraft attitude tapes are received from Goddard Space Flight Center. When the tape information has been processed onto in-house tapes, the originals are returned to GSFC. Routine data processing has essentially been completed from the start time of telescope routine scanning, 25 October 1967, to the time of the failure of OSO-IV's second tape recorder, 12 May 1968. Reduction has been delayed for the periods 28 February to 6 March 1968 (telemetry tape) and 23-28 April 1968 and 7-13 May 1968 (attitude tapes) because corrected magnetic tapes have not been received from GSFC.

4.2 Routine Conversion of GSFC Magnetic Tapes to Raster Format

4.2.1 <u>Raw Raster Generation Program</u>

The GSFC telemetry ("Main Frame") tapes are converted to tapes called Telemetry for the same time period at AS&E. GSFC attitude ("Subcom") tapes are converted to tapes called Aspect-Ephemeris (A-E) also for the same time period. The spacecraft attitude and telemetry data are then combined onto a single "Raw Raster" tape, and the information printed out with the use of the Raw Raster generation program. Two print sheets are required per raster scan, one for essentially the attitude information and the other for the telemetry readout, or raster scan, itself.

The following information is included on the attitude sheet: the date, the Universal Time (UT) of the first raster data word and day of the year to 3 decimals (1 January 1967 = 1), the filter wheel position as determined from the Analog Subcommutator (ASC) #5, the aperture wheel position from ASC #7, the filter wavelength interval, the ephemeris and aspect data at the start of the raster scan (angles in degrees and altitude in kilometers), the sidereal start time (UT) in degrees, the number of unintelligible raster scans skipped since the last raster on tape, the number of data words recorded on the present raster (1920 for a nominal scan), the number of questionable and missing data words on the raster as set in the telemetry tape by GSFC, and the average readouts from the four ASC voltage monitors for five equally-spaced intervals across the raster.

The raster scan consists of two-digit "words" in a hexidecimal code. The scan begins in the lower left corner with a 3-4 word signature. The recording time increases vertically up the first column, down the second, up the third, and so on until the end of the raster is reached in the lower right corner. Details on the spacecraft telemetry have been recorded elsewhere.[15] Figure 4-1 shows a typical raw raster scan.

4.2.2 Background Raster Generation Program

The Background Raster generation program uses only the Raw Raster tape described in the previous Section. The method for calculation of the average background raster is discussed in Section 3.0. Average rasters are computed daily from 25 October 1967 to 26 January 1968, and weekly thereafter. The time interval was

```
RAW RASTER SCAN STARTING AT UT  NOV  11, 1967   UT TIME  2  2 11.48          DAY OF YEAR 315
01 1/2 MIL BERYLLIUM          LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 1296.00/EPSILON
11 40 MIL APERTURE

     1       5         10        15        20        25        30        35        40
48   03030303010401010101010100020301040203040400000502020102020302030204040202020306  48
     00030000000001010304020502010304000402010202070304040302060004020305010206060805
     02020000040102030202020203030203010002030201020304030202040406020404030504030305
45   03060104060402030101020300040200030603020503020500040302060204000305050504060304  45
     01060301020304030200020101000402060400020305030402020401040305020302030402050604
     06030103030504050205030404060302030302040303030102000400060602060403060204010603
     05050501030002020304000204020204060102040000050302000102040203030503020103070406
     02030303050304030702020202040301030005020401030302040303020202020A04040703020606
40   06020604050508060301050003060405010402020200000204010302030505070303030005070604  40
     04020405040406050104020406010301040302040402060401040504040306060605050302090808
     06060905030508040503040404050301050603070105040303040103040406030403030508040705
     0807060E070707030305070605010004030203040304000302040202020104050407030602050801
     050508080A070605090403060203000305020306000204050402060504000403030608070806080 7
35   07080D0A14070D090702040302050202030104030603050704050607000304030503080106050 60A  35
     080B101117130C0F030507060502030201010503030404040301030304020206000605090507 0C04
     131324241D11150B04070503060505030404030402020403030202030402080405060407080506 08
     00182E2831120D0F000B050404050004030203050408030105020200030209030503050A060B0707
     1E24484D2F2F140F090809050204040301030303030302010004060005080505 0B06020408070905
30   131C3E52402B160E080C0305040205040304080401050303010603030409030609020508040A0609  30
     14254864583D1C130C080A04050904020204060105010304070201050402040 50B06050904070805
     19264760413420120609010204030203040403000904030301090304050606050407060E05060804
     1A313A604830130E0708060A09060305040605050302040501040804020703040407070906070807
     16333F433628181308080804010504030303060803010605000307050405080305090806040710 07
25   141A28391F1E12091C05060405050306030203020A03060604090403060308040604050E0C060607  25
     15142028171605110603030907080407010702040402010302070501090507 0A0807050A0C08070C
     0E151613131008061106090605050305080101030201050701040 30E0B070907050 30C080607090E
     0607140C0A0D020404060307020103020304050506050A05030402050805090803 0D080B090E0D11
     060A070B060A06070704040605040106030405020703020307050303050706050C0A0C0B15170C0E
20   07030C04080705040307030506020601040204020601050204000601050E090B0905140F11161911  20
     01040805030805040503020803080203030204020004030505050807080300040E11151827282B1E
     060506020603060504040203030303060200040404040201020304060509091008131623 2F2E411F
     06020905020402040906010304050306010204030103040903030705070 80D08060F152B46634324
     020401020402010501040201020101010408040602020304060905050207090B0C14163A484D4C42
15   00030404010402020206070403050402010404010806060103030505030 80C0C080E1534425A4A1F  15
     01030502030102040401010301020403030404060303050904040207040608070B0C151B3A473E26
     02030601050204020203040305050306010505010302090703040408060404060A0F0F14222E2A19
     000202000101070502010301060305020104050201040203040202080408080508090F08101F1313
     01040003010501020202010404010305020603030401050303050307070306050 60A0F14080E100B
10   02050502030002010303010302000100010103010201050402040309060702040707090C0B0D0C0C  10
     02030101030304010505010103070201010402040205040207030302030502080908070A0C0A0D07
     01000202020204040001040401000302050402030304040202020102050102070A0408040B090D0A
     03030100020205090404030000050202020402020400020202040704040404060405 0A0605 0404
     000302020300040201010100020204040302020202010604050102000504010203050A08060F0B09
05   00CCC00C0101020103020505010301070404040203000102020304070507060202060304070807 06  05
     FF0504060103010101020201000201010202020102060301040102030208030606060A0506030806
     FF010102020302010000010002000201030506010303050402010603030304020205060506060703
     FF020200000003010302000202010203070202040302030503010302030406060506040404060 70A
01   FF020103030406020100000103010001010102020103020102000304020204030604060806050802  01

     1       5         10        15        20        25        30        35        40
```

Figure 4-1. Typical solar raw raster scan (11 November 1967; 0202-0207 UT). The most sensitive mode of the experiment was used for this scan.

changed to improve the statistical fit, because of the deterioration in the detector efficiency. Two print sheets are again required for each average raster scan. The UT interval in both date and day number appears across the top of each sheet. The interval extends through one exact 24 hour day, or 7 day week, with no overlap.

Rasters are rejected by the program for the following reasons. The first part of the first raster scanned after the spacecraft reacquires the sun from a night side pass is unreliable. Therefore, these "sunrise rasters" are rejected from both the calibration raster and sun raster samples. Also questionable and missing data words are excluded from the sample.

A calibration raster is rejected if at least the first 20 columns are not present, if the average count per word exceeds 5 in the first 20 columns (this criteria excludes rasters obtained when the spacecraft is passing through the South Atlantic Anomaly - see Section 4.8), or if there are more than 100 interspersed missing and questionable data words. Also if the count per word anywhere on the raster exceeds 20, that word is rejected.

Only sun rasters obtained with the instrument in the 0.002 inch Beryllium filter and one arc-minute aperture modes are used to calculate $\overline{N}_{40\ sun}$. In addition to the calibration raster rejection criteria, the last 2 columns of a sun raster are removed if there are less than 40 complete columns (i.e., less than 1920 words). This is necessary because of anomalous noise at the end of such "short rasters". Data words are rejected if their count on sun rasters exceeds 10.

The number of rejected rasters and words and the number actually used in the reduction are listed on the first print sheet. Also listed are the values and statistical errors for $\overline{N}_{40\ sun}$, $\overline{N}_{40\ cal}$, and $\overline{N}_{cal}$. The raster scan itself is printed out in the same format as the raw raster, with the exception that each word is given in decimal notation, the first digit in units and the second in tenths. Figure 4-2 shows a typical daily average background raster.

4.2.3 Corrected Raster Generation Program

This program combines the information contained on the Raw Raster, A-E, and Background Raster tapes for the appropriate period, to produce a "corrected raster" or final x-ray filtergram of the sun. Again two print sheets are required for each raster scan. The attitude sheet contains the same data as presented on the equivalent raw raster sheet, with the addition of the value of $\overline{N}_{cal}$ used for the requisite average background raster.

The corrected raster program uses the following algorithm:

$$\overline{N}_i = N_i - B_i \qquad (4.1)$$

where $\overline{N}_i$ = the true count rate of a word i;

N_i = the raw count rate of word i from the raw raster;

B_i = the background count rate from the same position on the background raster.

A word is not printed on the corrected raster if either or both of the following conditions hold:

$$\overline{N}_i < 1.0$$

$$\overline{N}_i < 2\sqrt{B_i} \qquad (4.2)$$

Words are suppressed in this manner to make x-ray emitting regions stand out for ease in analysis, and to minimize noise counts. A printed word consists of a two digit decimal in log base 2, i.e., $\log_2 \overline{N}_i'$. Thus the data word 30 is equivalent to $2^{3.0}$ or 8.0 decimal.

```
TIME INTERVAL FROM NOV  11,1967  0  0   .0000 TO NOV  12,1967  0  0   .0000      DAY OF YEAR FROM

AVERAGE BACKGROUND RASTER

      1         5         10        15        20        25        30        35        40
48  15191418192220212123221125232126202521191925272427183228333131373231403131333233  48
    17181417222017221721191722182117172425251822252722242826292629302928293640413844
    16182018252318212418212318182025211824242225252425302627312629273632302736313440
45  23201816201815202117193122241818242123212622203127292632342227323731223835374841  45
    17141718202015242323212019172626192427282928322736213032313332273133343935423949
    16161722181718202122172118222326302626312623292923283027243027322729373942413745
    17181718182021182025221722221820262528272028272627322625352738313225323831444241
    12162214172024242521202223302425212628263127242529313130372828373435323543344743
40  18131823161823172018182220262125192326302722302333273128333133373740343244494743  40
    18231722202223211924262026242822231919222523282629262930373529353241383535464840
    13122122212122312528231820233023252034303028232928272825273239313141373839404241
    17181821212122232116282626222525232529302829302927342938353235353732404643424554
    22162020242220202325252725263130312626262628273227343734253625353035333637394147
35  16212119212926252623273024212622272826252329263030353837343230363538493846454652  35
    18272022171827212822222323242720232329302628323832373432313631353635393847505360
    17122217212521252926232628262825282926302938303226373236293938353241384747385453
    19202224232328232624222325281622342727313724232934313329393641373739425051455454
    23192018132726272026202325232032272730253336293631322831272934424135544047515857
30  17151619252927222222252723262428272531332931282431323130323433423740435155545266  30
    22131719192322192627231825252827212630273032283033312831283934334444543852656164
    24122017242222222322252130262328282626323127353634303238393837403647455154595659
    17172316232525182221252930272225322728282832363334353435363137484755594552595753
    23222517192921232021222323253025252733272720313236303433424333354749546463626666
25  21181920202421222630262727242530332230252724322533343032343443444857525359617771  25
    24181820172220232226252322192128253033272129263430273134444137494545535658596272
    16231721172422181618232223233132322823323028323233333640344136465744586566587772
    15201720212322202225262022273124263127273035312833263236324843505355556267656876
    15171624192323282026242422262526312732282829252934253841344144445050595954586775
20  20201527162923272121212927252826292522332831283223313835343738464650585158677069  20
    16251523171924222020203018242228252430272822323231303637404152474455596267656079
    17191817161621182223191718202522252127253026322738373536303952455151525662696969
    22152220182020211520232226273022222527302623343430443840353746514854595661586576
    18162417262117142022282418262322262429242332283132263942414139405453515764655766
15  14131814182321222020171524262322222325242821313523303034404047505351565559707472  15
    22151916222121201918251718182522252223242729322333323136394140394258484759706387
    13211520172019202118212015232020242526232026222831273028414141373849566055645777
    13151817171722211820261822242323212117332630272229283031403845434044466055557270
    16161722161217241823222618242115202024302319212727272033383331434443465458556269
10  17191515181912201623251918192616222721212524222726282433254438414052505454667678  10
    20171622131317251717152418201818212325212323252629273326313535424151545254666868
    22131617151515141216181824212216172119222328223131233128263543413547474849565774
    06201411172019172017182220202020202427212324192626253126313035404641425145626870
    04141512161713162025182021181916211820172125222417322829313831323544434458566370
05  00181216121017151713172217142122192215152519272725302528333634413837464451636360  05
    00131614171411171618202016211717241822202021182125202317232734313637444352475469
    00131117121116131316171815171820161615212026172017162727292828413327423948495161
    00171219121710151319152017231519152216202020202524192527303331303227414553534668
01  00131614111611141715181617152215161817221218192123242325262924282828423939494756  01
      1         5         10        15        20        25        30        35        40
```

Figure 4-2 Typical daily average background raster (11 November, 0^h UT, to 12 November 1967, 0^h UT).

Typical corrected raster scans appear as Figures 4-3 to 4-8. These 6 scans show the development of flares in 2 active regions for the time period included in Figure 5-4. Figure 4-7 was produced by combining its equivalent raw raster (Figure 4-1) with the daily average background raster covering the same time period (Figure 4-2).

4.3 Fulfillment of NSSDC Requirements

Raw raster and background raster data tapes have been submitted to the National Space Science Data Center (NSSDC) as required in the Statement of Work. A card deck of the corrected raster program (see Appendix) was also included. The tapes are complete for the period 25 October 1967 to 12 May 1968 with the exception of the gaps noted in Section 4.1.

4.4 Active Region Ring Integration Routines

4.4.1 CalComp Plotting Routines

A major effort of the reduction program at AS&E has involved the generation of x-ray intensity vs time plots of individual emitting regions, followed for periods of up to 60% of a single solar rotation. Several regions have been followed for more than one rotation. 32 regions have been plotted for the time period covered by this report. A list of the regions followed and the periods covered are given in Table II. Most have been analyzed in detail and the results appear in Section 5.0.

The plots are produced in the following manner. An active region is selected for study for various reasons, mainly based on its overall intensity and level of activity over an extended period of time. Once the region of interest is selected, its approximate center is located in arbitrary raster coordinates on the corrected rasters. The coordinates of the center are then listed as the region moves across the solar disc.

TABLE II

ACTIVE REGION TIME HISTORIES LIST

McMath Plage No.	Approximate Period Followed (1967)
9034	28 Oct., 9^h - 1 Nov., 9^h
9047	27 Oct., 6^h - 12 Nov., 19^h
9062	10 Nov., 0^h - 16 Nov., 21^h
9073	10 Nov., 0^h - 27 Nov., 11^h
9082	17 Nov., 16^h - 4 Dec., 0^h
9088	24 Nov., 15^h - 4 Dec., 0^h
9091	24 Nov., 15^h - 4 Dec., 0^h
9101	1 Dec., 15^h - 14 Dec., 14^h
9107	5 Dec., 11^h - 6 Dec., 21^h
9108	2 Dec., 11^h - 17 Dec., 0^h
9110	8 Dec., 16^h - 12 Dec., 8^h
9115	8 Dec., 16^h - 23 Dec., 23^h
9118	12 Dec., 5^h - 17 Dec., 0^h
9128	25 Dec., 5^h - 31 Dec., 6^h

McMath Plage No.	Approximate Period Followed (1968)
9132/3	2 Jan., 23^h - 6 Jan., 6^h
9146	2 Jan., 23^h - 19 Jan., 12^h
9184	26 Jan., 6^h - 1 Feb., 20^h
9188	29 Jan., 23^h - 11 Feb., 5^h
9204	8 Feb., 11^h - 22 Feb., 23^h
9222	18 Feb., 8^h - 28 Feb., 8^h
9224	21 Feb., 0^h - 28 Feb., 9^h
9225	22 Feb., 18^h - 28 Feb., 9^h
9267	10 Mar., 21^h - 22 Mar., 6^h
9273	23 Mar., 3^h - 1 Apr., 6^h
9281	21 Mar., 10^h - 27 Mar., 0^h
9285	19 Mar., 2^h - 3 Apr., 15^h
9286	24 Mar., 0^h - 6 Apr., 3^h
9313	8 Apr., 8^h - 23 Apr., 2^h
9337	24 Apr., 13^h - 30 Apr., 10^h
9358	30 Apr., 21^h - 9 May, 20^h
9364	27 Apr., 10^h - 12 May, 23^h
9372	3 May, 1^h - 10 May, 11^h

```
CORRECTED RASTER SCAN STARTING AT UT  NOV .10, 1967   UT TIME 15 57 33.18
01 1/2 MIL BERYLLIUM            LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 7060.00
11 40 MIL APERTURE              EPSILON =    .18           N BAR CAL =     .88

     1       5         10        15        20        25        30        35        40
48   ------------------------------23------------------------------------------------ 48
     ----------------17--------------------------------------------------------------
     ------------------------------------------------------------------------22------
45   --------------------------------------24------------20------------18------------ 45
     23------------------------------16----------------21------20--------------------
     ----18--------------------17----16----18----------------------------------------
     --14------------------------20----------------------------------------------25--
     ----------------16----------------20----23--------19----------------------------
40   ------------------------------------------------------------------------------20 40
     ----------------------------21------------------------------------------29------
     ------------------------20------------22----------19----------------------------
     17------18--23--------15----------19--------------------------------------------
     --------24--------------------18--------------21--------------------------------
35   --16----25----17---------------------------------------------------------------- 35
     --------29------15--------------------------------------------------------------
     20--------------------------------------------19----------19----19--2121----27--
     ----------20--------------------------------------------------------------------
     ----1629202320------------------------------------21--------------27------------
30   212226--252228----------------------------------------------25----21--------27-- 30
     --213318383225------17--------------------------------------------22--26--------
     2016323742393327----19----------------------------------------------------------
     --2032304340302720--------17----18--------------20----------------------28------
     28282539372922--------------------21--------------------------21----------27--24
25   1628234134322015--16----------------------1827------17----------------26----2430 25
     ----26301622271916--------------------------------------31----20----------------
     --2223--3218----------22--------20--15----------------19--------23--293024------
     --20--2028--20------------------------------17------21----30--232830--25--32----
     ----21--24----------------------16----------------------31--2824--23--232827--34
20   --151721----------------2219----17------------18------------28----35322940273934 20
     ----15--------16------23------------------17--------------22----2936434150454943
     ----------------------------------------------------24----2126233229424754585841
     ----------13------16------------17------------------------------2941405257646353
     --18----------15--------------------------------------------25----29415164626356
15   ------------------------24--------19--------21----------27--27--3536435463646354 15
     ------------16--------------15------23--15----18--------21--26263124425655605950
     --------------14--------------------------------------------------32424553544948
     13----------16----------------------1616------------20----27------24263837464042
     ------------------------------------------------1822----21--29----24--27--332736
10   15----------------------------------2415------------------------------283733---- 10
     ------------------------------------------------22--------2021--25--------------
     21----------------13--1821----------------------18--------------------2923--28--
     --------------16----------------------28--16------18----22--26------------26----
     00--------------------------------------15----------------25------------23------
05   --------------------------------------------------------------------21---------- 05
     D8------------------11--------------20------------------------24----------------
     D8------------------------------------------------------------------------------
     D8----------------------------------------------------25--------------20--------
01   D8----------------------------------------------17------------------------------ 01

     1       5         10        15        20        25        30        35        40
```

Figure 4-3 Corrected raster, or solar x-ray filtergram, for 10 November 1967, 1557-1602 UT. Note the two active limb regions: McMath plages 9073 (left) and 9047 (right).

```
CORRECTED RASTER SCAN STARTING AT UT  NOV  10, 1967   UT TIME 19  8 31.08
01 1/2 MIL BERYLLIUM            LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 7060.00
11 40 MIL APERTURE              EPSILON =    .18           N BAR CAL =      .88

     1       5         10        15        20        25        30        35        40
48   13--------------------14----------------------------------23--------------20----   48
     --------14------------------------------------------------------19--------------
     ------------17--16----------17----------19----18--------------26----------------
45   2121----------22--------------------26--15----------24--21--20------------------   45
     --------1418------24------17----16--------18------------------20--24------------
     2727------------------20--2423----------------------------------2521----------23
     131820----24--28--------------------------------------------------30----23------
     --------18--1617--21--17--------------------------22----23----------21----------
40   2826--1918----2020--24--------------19--------------26--27----------------------   40
     21312821261723--1929----2016----------------20------18--29----------------------
     30--332827--2030--1921--------------------------21--2420------------21--23----20
     27--263527282627------19--2218------18--------20----------21--------------------
     30283440373329----16152317--15------------------------------------252629--------
35   3226323641422529------2220--25--231824--------------------24----------2920------   35
     353843464545343632192223----------------2826--------------------19--3024----41--
     3937475053504342373018--27----20----------2422------------22----27----21252229--
     374047505753453735272423----------------------2420----21--------20----21--------
     4346505761585139--2921----------------------------------------------3024----26--
30   294559576057503932262734------------24----18------22----3526------32--2533------   30
     495057616158544440352421262025--40----2926------27----1927------292726----26----
     3650566060554835382929------23--22--------202123--2024--1930242729--29--24--2432
     4653616161544742363030------152418------------------------3126282821----38327932
     50566265655840402134193617------25------1726--23--29----2221----283122--28413727
25   45556162635544424323--22------------------212223----1725----2626--243132353331--   25
     4050606160514139--292630181926------1823----2126--203427193638282734393039273242
     4147545647504227252429----18--15--------1822----20----25--3029273234324149424145
     4047475545452833272728--15----2422--------22----24--21223423--333636443846454645
     3136374737334135222836--------29162816--------27--2829--313335394242494856545748
20   242834392626--15------------------------2522----23222936273536434338515063606059   20
     --29153031301620--202623--------2417--29----18----243134--3835374648545967717364
     --2620272015--22------17----20----2120----22--2421--2430303836464654576577757971
     25--2420--22--17----19--------27171815----24--2321--28--333233344945606981818474
     --1826----24------------20----------------15--23--232128322541404856627182818278
15   ------22--17--20------21------19--233023----182820--29--373435393750617079848176   15
     --26--17--2120--14----------------------15------27252430262836364554576374797670
     --181616----------------1819--------------------17--2423263029454043526065736860
     --14------------------2618------------23--23--20----23--3140--382944475454626057
     --------------17----18--------15--2126--24------31--2920293132414138365250545048
10   ----------21------23----21------15--261518----26------2121323030--31444446504544   10
     ------------13--18--13----161716----2015--302922----212022--3024--44313840384044
     --1121----------------13--1721--26--2020--------------2720--2528362531342333--29
     --------19----------------------16----------------1824--34----292823413529--3832
     10--1510------14------22------14----------------241724----2221272535272730293226
05   ----18----23--------15----1420--------------19------------------33--293327--25--   05
     D8----------17------11------------25------------------18----21--------22------27
     D8------------18----23----------------2516------20--18------26----2523--------29
     C815--15----------18----------------------------20--------22----243229--32----25
01   D8----------------------19----------------------24------------------------27----   01

     1       5         10        15        20        25        30        35        40
```

Figure 4-4 Corrected raster for 10 November 1967, 1908-1913 UT. A flare in region 9047 (right) is near its peak on this raster.

```
CORRECTED RASTER SCAN STARTING AT UT  NOV  10, 1967   UT TIME 21  4 44.16
01 1/2 MIL BERYLLIUM           LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 7060.00
11 40 MIL APERTURE             EPSILON =    .18          N BAR CAL =       .88

    1       5         10        15        20        25        30        35        40
48  --25------------17------------------------29------18----------------------------  48
    ----14--22--20----------------------------------------------2323----------------
    ------312227--16----------------------------------------------28----------------
45  17--------16--13----16--16--------23--------------22--------------------------27  45
    151418--2522--17------19----------24----------------------------22--------------
    --142117----2417------------20--20--16------------26----------21--------22------
    3118302617----20----21--18--15----18------------------23----22------------------
    292917262718----20--1729161818----15--------------------------------26----------
40  2426323427252928--26--18------------------20------------------------21----------  40
    27313027--3428--1931231615----18----------------------24------------------------
    282237322933363032----21----------1820--------18----17--------27----------------
    40353927413336293615------25--------------------------------32----------23------
    383939333745332632242023312015----18----------------------------21----25--------
35  395C494648433834--32242923--------24--------------------------------------------  35
    4348535457495240361927----331927--18--2819--21------------------28----------23--
    44546064625347492932292518----1619--18------------------19----2519--------------
    50566669686254463634261522--172030------------------------22--19------24--------
    536066747267604532342130------1829--18--------2320------------------2024--------
30  5362687374696150434129272726----2423------18--21--25--------22--------22--26----  30
    456269747568594735362818152027------29--2620------23----2120--------------------
    55606871736649464432223720302016--232118----21------20--1920--29----------32----
    5061707169635348423933--21----2118--18--21--------------------25------23----29--
    516166686759514543383427--21--19--2122----------2419----22----24------2723--29--
25  495962646457504135321829--24----22--232020--29--------22--23--2330--2430--------  25
    485660625951473338322130--23----17--------------------------242834----322532--39
    43535157474645353131--2720--26--26----------21--23------27--24272326273828283328
    35424846464043333121--25--------19--------18--------212221--25303031294137373829
    392830362933372732321727----17--------22--20--22--------312626242638444042363834
20  21333735163631202324------2718--27--------22271820----24272328273529434444474445  20
    20252620--20302322----15--------------2722--------------------302931445157616253
    --2123--2033--19--261628--1916----21--20--------17251723--21--303039495364666559
    132324162113--272016--1922--18--17--15------------------32--32--4443495669696361
    --272625--28----16--15----------20--------------19--------2225383738496271716961
15  --20----16----23----2017------------26--15--21--------232421--312438506470696757  15
    16----1716----212219--2015--33------------19233132----2324--34283141485760696361
    ------------------16--------18--------25------------17--203231--3534395154625353
    ----16----------------------------------15--1524----32--19222428--31364549464537
    ----17----------------21----16--18----20----20----------24----19--31343442364226
10  ------------------16------------------20----16----24--------26--2629313034383629  10
    --------------13----22241816----------15----18----20----2523------2033--332934--
    2121----13------------25------22------16--------1827------------------3328--32--
    ------101415--------18--------------1616--20--1521----------21----233134--------
    --------------------------2617--------------------------17--27----27----263225--
05  00--------------------------------------------18----------21----------2327--29--  05
    D8--------------------11--------------20------------------24----29--------26----
    D8------------------------13------14--13----------------1817--------28----------
    D8--------------------------------17----------22------18------19------28--------
01  D8--------------------------------------18------------22------------------------  01

    1       5         10        15        20        25        30        35        40
```

Figure 4-5 Corrected raster for 10 November 1967, 2105-2110 UT. The bright x-ray flare in region 9073 (left), evident in Figures 5-3 and 5-4, is near its peak on this raster.

```
CORRECTED RASTER SCAN STARTING AT UT  NOV  11, 1967   UT TIME  0  5 58.49
01 1/2 MIL BERYLLIUM           LAMBDA 1 =  2.00   LAMBDA 2= 13.00    KN = 8311.46
11 40 MIL APERTURE             EPSILON =    .15          N BAR CAL =     .75

     1       5        10        15        20        25        30        35        40
48  ----------------------------------------------------------------------------22--  48
    ----------15--------------16------------------17----21--------------------------
    17--20--------------161821----------------------------------20------26----2022--
45  ----17--------------------27--------------20------------19----------------------  45
    2414------23291919------161718--------------19------------------23--------------
    ------28--------------------------------18------------------------------2523----
    27--29----------16------15--------------19----------------17------17------------
    2313----18----18----------------------------18------------2624------------------
40  17--20--27342321--24----16------------------20----------------------22--------25  40
    1725242628--222624--21--------------------19----24----------28------------------
    223420----16222023------------28--26--------------------18----------29----20----
    37281638--3333223024--------------22--------20----------------------------------
    3336362634332830----------------------17----------------18----------1922--------
35  3641393241303621211524--2323--22----------------------------20------------22----  35
    354151525041393324----------251625------------21----22--26----25------24--------
    4242565652514634342929182118----------------26------------24--------20--------25
    475561636152433932331927--2418--------------------24--------------------------27
    485661676460514437182625--------------------------------------------------------
30  53566767686054423633--21--2522------------22--------------------24----------23--  30
    5159677070615244402728262118--21--------26----------24------2228------28--------
    495667716461524637273330----19----17------------------------24----------25------
    48596668676151452815--------------------21----25--25----------------------------
    445860686359464726281518--18--27222423--24----------------------21--------------
25  505362645653494229232127--2918----------------27------------------31--------29--  25
    41545458574939253325--19--21------24----25--24------23----------212529----24----
    4246515248424135213326------------------20--------29------23--------------24----
    38444545433336233425182320------29----21----------27--------25--28------27243127
    34323834333134172832--22------18--24--17--------------------------35--2431383229
20  283027253224--1719----------------2223----------2228----27--26--2923383035373739  20
    24272922253522--20----20--22--------------19--------------30----25--393839494845
    --242921--241527--27--17--------------25------24----------20--22--26324453525450
    --1823--2024--23------------------2524----2719----------2721------29335459606052
    24----------17------17----------18----2522--------17--------2033--31445862616252
15  ------14--------------25----23----15--18--26----18------26--21----38475665625856  15
    --------------23--20------21----1819--29--------------------------28395359645750
    ----25162126------17----14----15----27--28--19------23------23--29----3853574844
    ----------17----1716----------19------2525----15----------24----2025273943434326
    --18----18--------------20------24----------------2728--21--23--31----22373530--
10  ------1826--------------------------------25------21--------272823--------38----  10
    ----------19----------22--------------20--------20--------------------3425--28--
    ----1821------1819--------------2916--------------------------2622------2629----
    --23----------1816----------------------------1822------------------30--34--30--
    ----------21----------16--24------1620--16--------------------27----------------
05  ------------------19--------------------------------------------2421------------  05
    D8----------15--13--------------------------17--18--------------------------27--
    D8--------------------------24--1313--15----172321--------------------2428------
    D8--------------------------13--------17----------------------------------------
01  D8----------------------------14----------------------------------------20------  01

     1       5        10        15        20        25        30        35        40
```

Figure 4-6   Corrected raster for 11 November 1967, 0006-0011 UT.

```
CORRECTED RASTER SCAN STARTING AT UT  NOV  11, 1967   UT TIME  2  2 11.48
01 1/2 MIL BERYLLIUM          LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 8311.46
11 40 MIL APERTURE            EPSILON =    .15          N BAR CAL =     .75

     1       5         10        15        20        25        30        35        40
48  --------------------------------------------------------------------------------  48
    ----------------------18--------------------22------------------------------28--
    --------------------------------------------------------------------------------
45  --20----20------------------------20--------------------------------------------  45
    --22--------13------------------21----------------------------------------------
    21--------18--16--15------19----------------------------19----------------------
    181717--------------------------18----------------------------------------------
    --------18------22----------------------------------------------27--------------
40  21--20--18172621----16----18----------------------------------------------------  40
    ------16--1816----------18------------------------------------------------22--20
    222328----1625--------------------20--20--------------------------------21------
    27242036232323----182018------------------------------------------19------------
    151826322923201627----17--------------17----------------------------22--21------
35  253235304120342721----------------------19----20--------------------26--------23  35
    2631383944413237----2319----------------------------------------------24----28--
    4142515148394235--21----------------------------------------21------------------
    35455552554034373431----------------------25----------------23--------24--27----
    4851616255554136282528------------------------------------24----28--------------
30  41475963595343362533----------------23--------------------25----24--------------  30
    4152616664594741322430----27--------------------19--------------28----24--------
    45526166605649401927--------------------26--------27------------------32--------
    4656586661554136232618282618------17----------------22----19----------21--------
    4356596057524541322626----------------24--------------------22--------------32--
25  424652584948402837--17------------------28----18--25----------------3126--------  25
    424249524443163920----282327--20--20--------------22----22----24------26--------
    364243414138252139202820--------23------------20------3329--24------26--------27
    222442333034------18--23--------------------28----------30--23----2925----292732
    223125312029182123----18------18--------21----------------------282426244041--27
20  24--34--272015----23----17--17----------17----------------34242722--383335394233  20
    --1827----27----16----23--25------------------------21--20--30--3235394250515245
    211621--21--2017--------------19--------------------------24--35--38414953535946
    19--2816--------2921----------19--------------25----------213126--33395260655948
    --------------18------------------25--18----------27--------23282739415760616159
15  ------14----------202414----------------2420--------------2029282532405559646146  15
    ----17--------------------------------18------27------------20--2826404557605849
    ----22--18--------------18----20------------2820------24--------2733323848535241
    ------------2315--------19----------18----------------23--20----2022342434473636
    --13------19------------------18--20--------16--------19----------253439--3133--
10  --1618--------------------------------------15--------2518------------272527----  10
    ----------------1717------23--------------------20------------2823------27--26--
    ------------1414----------------18------------------------------27------26--29--
    13----------1729----------16------------------------20--------------26----------
    ------------14------------------------------20--17------------------25----32----
05  --------------------17--------22----------------------21------------------------  05
    D819--22----------------------------------19--------------24--------25------25--
    D8--------------------------------1821------17----------------------------------
    D8----------10------------------25----------------------------------------------
01  D8--------13----------------------------------------------------17----28--------  01

     1       5         10        15        20        25        30        35        40
```

Figure 4-7 Corrected raster for 11 November 1967, 0202-0207 UT. Compare with Figure 4-1, the equivalent raw raster scan.

```
CORRECTED RASTER SCAN STARTING AT UT  NOV  11, 1967   UT TIME  4 48  4.25
01 1/2 MIL BERYLLIUM          LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN = 8311.46
11 40 MIL APERTURE            EPSILON =    .15         N BAR CAL =      .75

    1       5         10        15        20        25        30        35        40
48  --------------------------------------------------17------------------------22--  48
    18----------------------------------------------------21----------------------22
    ----------------------------------21--------------------------------2021--------
45  ----------------------------16------------------------1919--------------21----23  45
    --14------1613------------------17------------24--------------------1926--------
    ----------24--------------23------18--------------------------------------------
    --------------------19----------------------------23----------------22--20------
    15221913----22------------------------------------------------------19----------
40  ------19--------------------------------18--------------22----------------------  40
    ------23------23--------------------26------------------------------------------
    25------1520--------18------------------------------------------------------2326
    ----16262015----------------------------------------24--------------------------
    2327162318--2316----------------------------------------------------------------
35  --202324--26--2430--18------18----------------23------22--------------2724------  35
    21182631262427--31------19--------19------------------------------------31------
    2726393633382025----25--------29--------------------20--------22----20--32------
    323648414137172522----18------------------22----22------------21--20------22--22
    31454351423618--1618--22--------21--------------------------------22----29------
30  374448505547383025--252122--------------------------------------2420------------  30
    3849495653494335292419------17--16----------------------21--2219--22--28--25----
    18455054534639383425--23--------17--------------------------24------------------
    4348535352453835332624--------21------------------------21--27------------3330--
    365454505045453320------------------------15------------30--2922----25--2730----
25  384649474846323321--29----18--20--19----------21------22222729------2322--33----  25
    343735464940352720------1917------20----252324------------------2722--24--2429--
    3535384634372521272028--------------19----------------24--2021--2427------3232--
    273738483219262019----------------------------------22----------28--29--35--3427
    2518292733----29----18------------------24------------------222223--283044383229
20  --20182524--------2020--17----------23--17------19------2728--243130--3348384436  20
    ----25--1827------1523------16--22--------------------21--26----3232364250556043
    2416--21------24------21----------1525------------------------333235375056656551
    23--------------1821--------------------------------------2832303535495763646560
    ------------21----------18----------23--27----------------302826--39415464666656
15  14--21------------16--14--------------1828----------------2332302523444860666056  15
    --------------16----22----------------18----------------21----282833325256575653
    15--18--1816--------23--14------------------23--------------23303432343947534847
    ------------30--------16------------------------------30----272528--273238444345
    --------------19----------------21--22------------------21--1922--222429363834--
10  ------------------------17----17----------------------------2120--23--3127------  10
    --------14----------18----------------20----------------------23--25--253127----
    --------141414------------------------------------19----27--22--------35--2434--
    ------10----21----------------20--------23--------------------------23242130----
    07--------------------16--------28--------1820--------20----20------------------
05  16------------------------------------------------------2224--------------------  05
    D8--------------------------24------23----------2520------17--------------------
    D8----------13------------------------20----17------------------------------23--
    D8--------------14----------------------16--24----------------------23----------
01  D8------------25------------------26--------------------------------------------  01

    1       5         10        15        20        25        30        35        40
```

Figure 4-8   Corrected raster for 11 November 1967, 0448-0453 UT.

A region can generally be followed for as long as desired until it rotates around the limb of the sun. However, several factors limit our detection ability of these regions. The primary problem is the decay in detector sensitivity. Nearly half of the regions were studied during the first two months of the spacecraft's lifetime, when the sensitivity was highest, and thus statistical fluctuations in the count rate were lowest. The instrument aperture mode is an important detection factor, because the 4 arc-minute aperture mode has 16 times the flux gathering power of the one arc-minute mode. The filter mode is of lesser importance for this process, since only 20.5 minutes will elapse between filtergrams taken through the most sensitive filter. Rasters obtained with high noise counts (see Section 4.8) limit the number of rasters available for analysis. The greatest number of "noise rasters" are those acquired in the South Atlantic Anomaly; typically these rasters account for 15% of the total number of rasters obtained daily.

The list of center coordinates and the duration for each coordinate for a given emitting region, are entered into the particular ring integration program desired. Three tapes are used with these programs for the period of interest: the Raw Raster and Background Raster tapes, and an empty tape on which is printed the program results for use on AS&E's CalComp plotter. Raw raster rejection criteria are the same as discussed in Section 4.2.2.

The ring integrals are calculated in the following manner. The coordinate of the center word is defined as Ring 1. Ring 2 consists of the 8 data words surrounding the center word, Ring 3 the 16 data words in the next square ring outwards, and so forth. The total uncorrected ring integral is then formed by summing the contributions from each ring over as many rings as desired.

Generally the integral is taken to include 10 rings. Ring sums are calculated about the same central coordinate independently for the raw raster of interest and its corresponding daily average background raster. Then the background sum is subtracted from its corresponding raw raster sum for each ring sequentially outward from the center, and the remainder integrated. If at any time the remainder for any ring is ≤ 0, the integration is truncated at the previous ring. The program is required to integrate to at least 2 rings, since occasionally the central word (Ring 1) remainder is ≤ 0 but contributions can still exist in outer rings.

Finally corrections are applied to the integral to account for the decay in detector sensitivity and the point source response function (Section 3.3.1). The results are printed out in a format that lists for each raster scan the date, the UT and day number of the beginning of the scan, the filter and aperture modes, the integral with the number of rings counted and its statistical error, and the corrected value with its error.

The final output is generated on the CalComp plotter. These plots present the time history of an individual emitting region. The corrected counting rate integrals are plotted on a vertical log scale vs a linear time scale. Corrected integral values less than 100 counts/0.14 seconds are not plotted, because of their low statistical significance.

Three different programs determine which filter and aperture mode combinations are to be displayed on these plots. For all emitting region time histories, plots are produced which display all filter and aperture mode combinations with error bars. The upper half of Figure 5-4 is an example of this type of plot. A second program plots only those integrals obtained when the instrument is in its most sensitive filter mode (0.0005 inch Beryllium).

Both aperture modes are used, but error bars are not printed. This program uses a linear time scale of 0.5 days/inch, whereas the first program uses 1.1 hours/inch. This scale reduction allows one to easily detect systematic long-term variations in the emitting region.

Typical examples of this compressed time scale type of plot appear as Figures 4-9, 4-10, and 5-3. Typical error bars are shown on the right side of Figures 4-9 and 5-3. Figures 4-11 through 4-26 are tracings of the important active regions followed during the period covered by this report. All of these tracings are drawn in the 0.0005 inch Beryllium filter and 4 arc-minute mode.

The 0.0005 inch Beryllium filter plotting program was not used for emitting regions studied after the end of January, 1968. Instead another program was used, which plots all integrals acquired with the 0.0005 inch Beryllium and 0.00025 inch Mylar filters in the 4 arc-minute aperture mode only. This change was dictated by the reduction in detector sensitivity, which decreased the detectability of non-flaring emitting regions through the one arc-minute aperture. The Mylar filter transmits at least 70% of the incident flux of the thin Beryllium filter, and is therefore useful for filling in time gaps on the plots created by the elimination of the one arc-minute integrals.

4.4.2 <u>Raster Active Regions Summing Program</u>

This program performs ring integrations of up to 7 selected emitting regions on a single raster. The appropriate raw and background raster tapes are used with the following input data: the day number and UT of the desired raster, the number of regions on that raster for which ring integrals are needed, and the center coordinates for each region. Any number of rasters

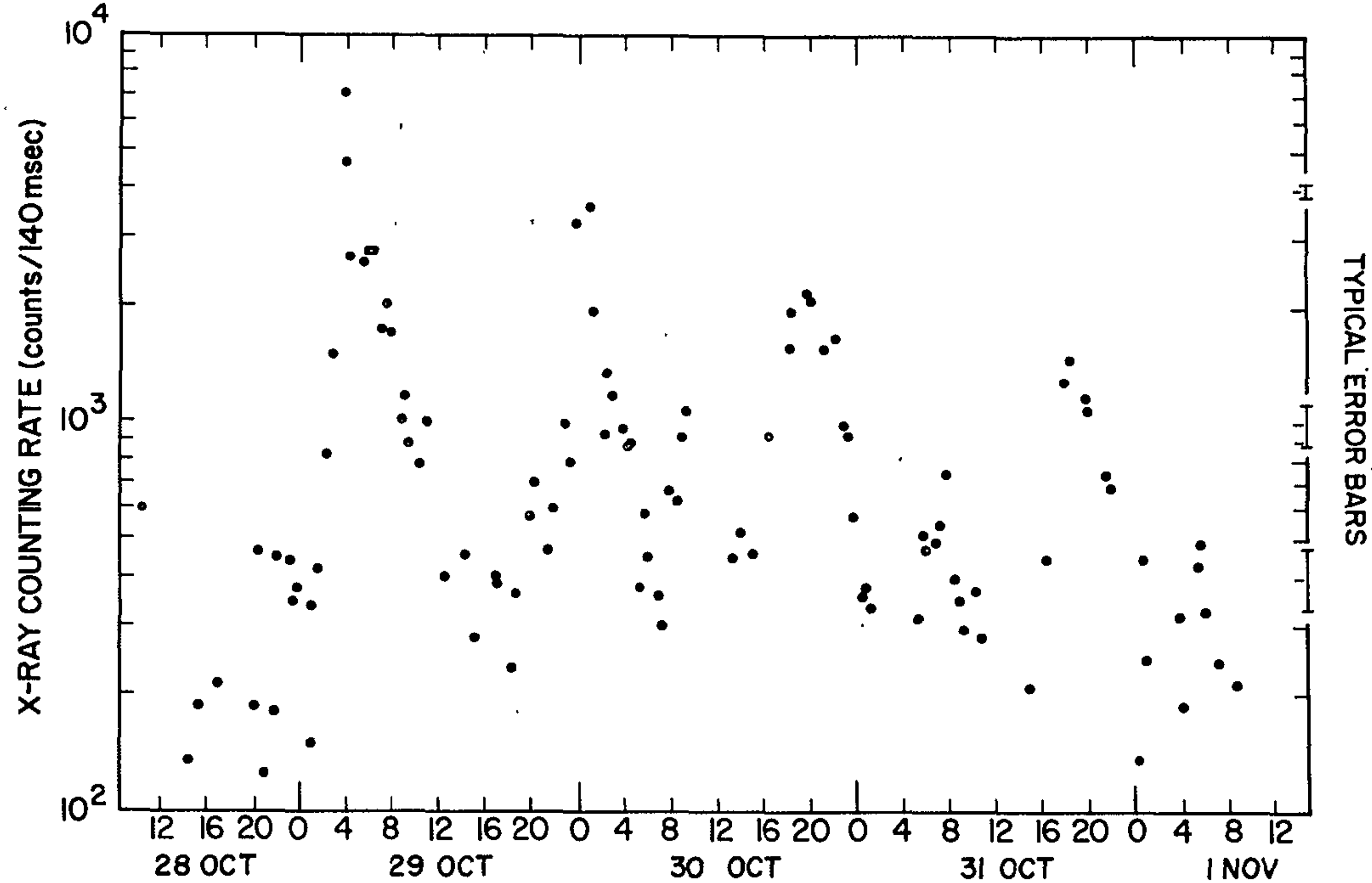


Figure 4-9. Time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9034 in late October 1967. The aperture mode is one arc-minute. *Typical error bars appear on the right side.*

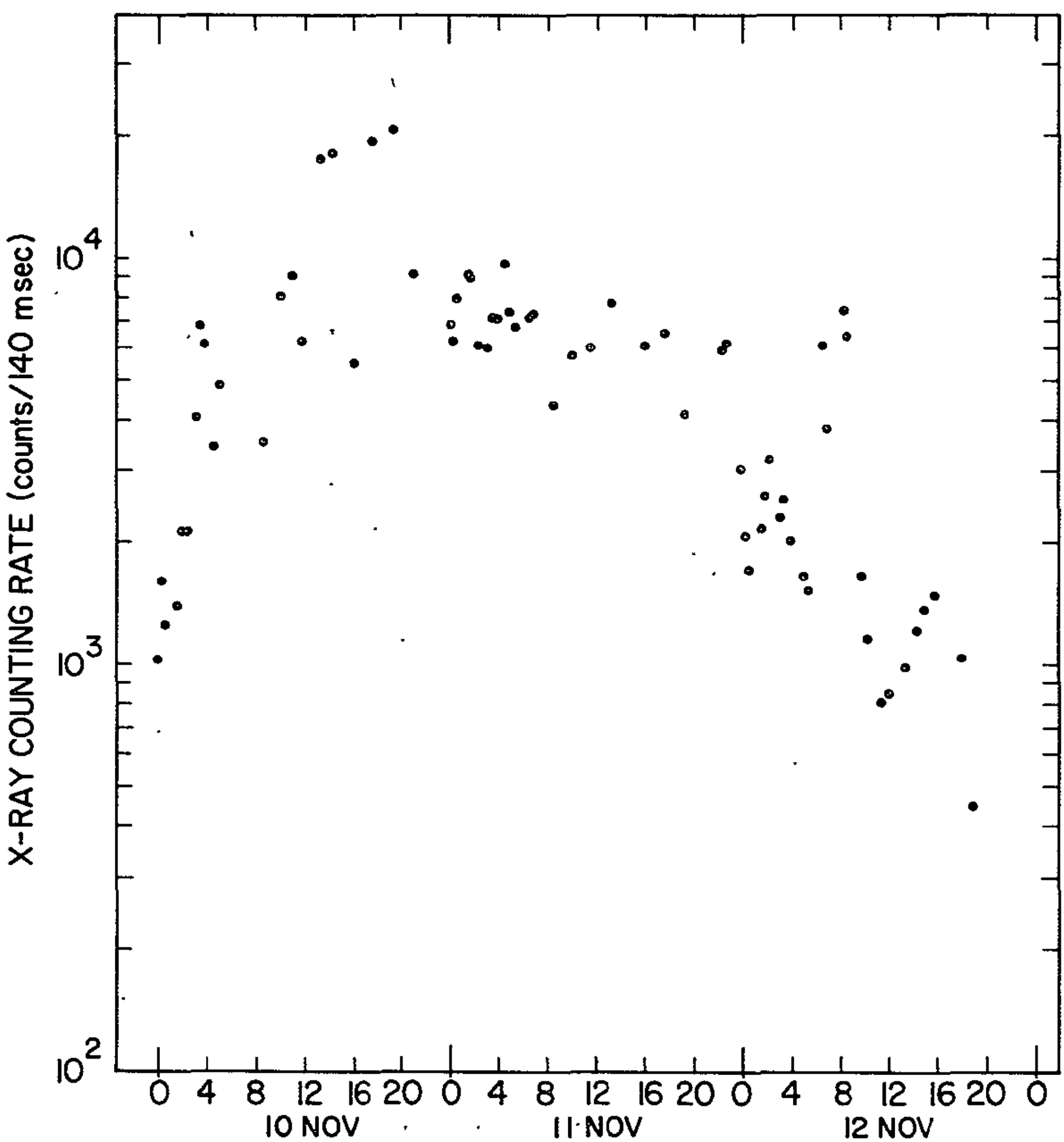


Figure 4-10. Time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9047 for 3 days in November 1967. The aperture mode is 4 arc-minutes.

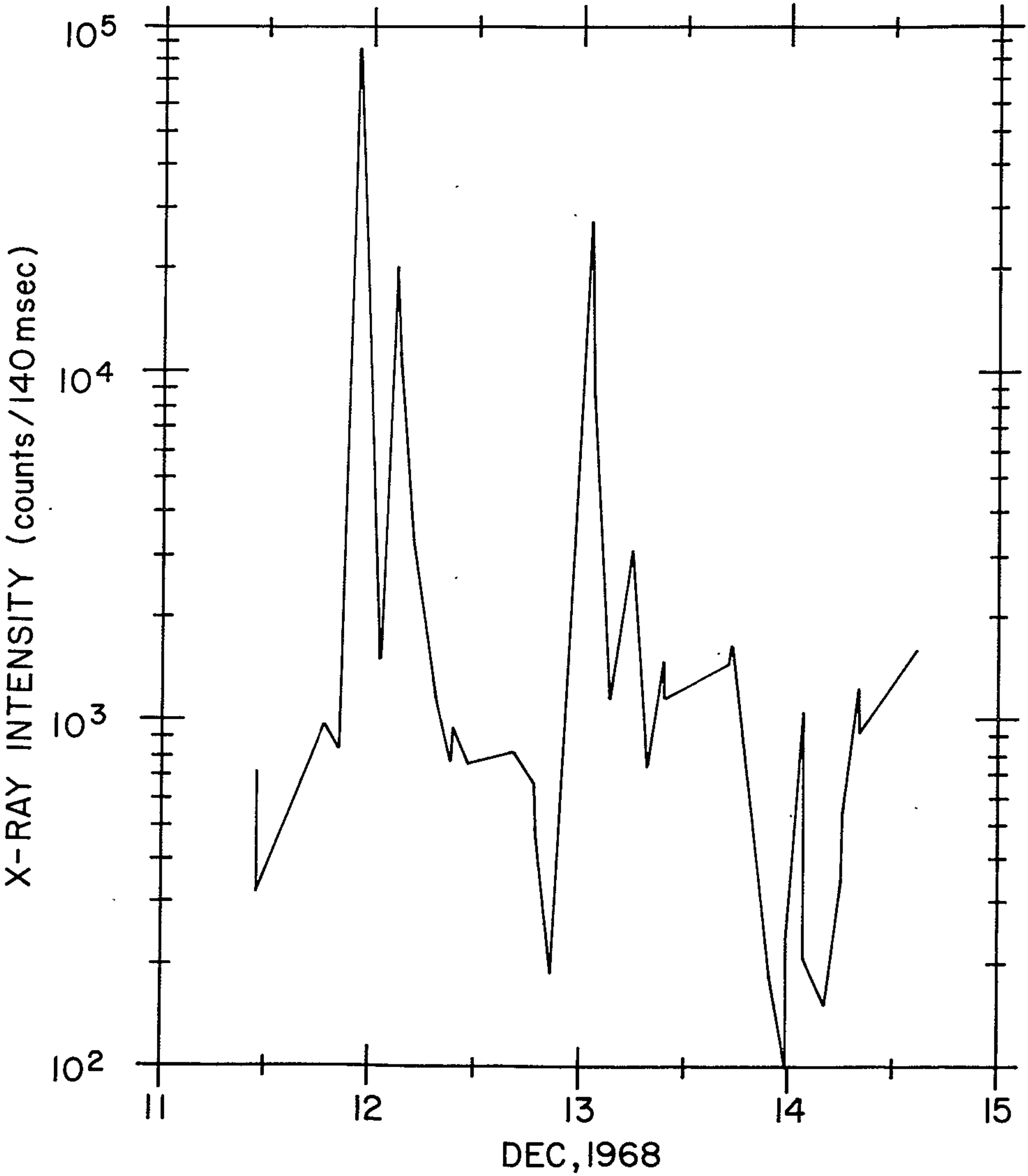


Figure 4-11. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9101.

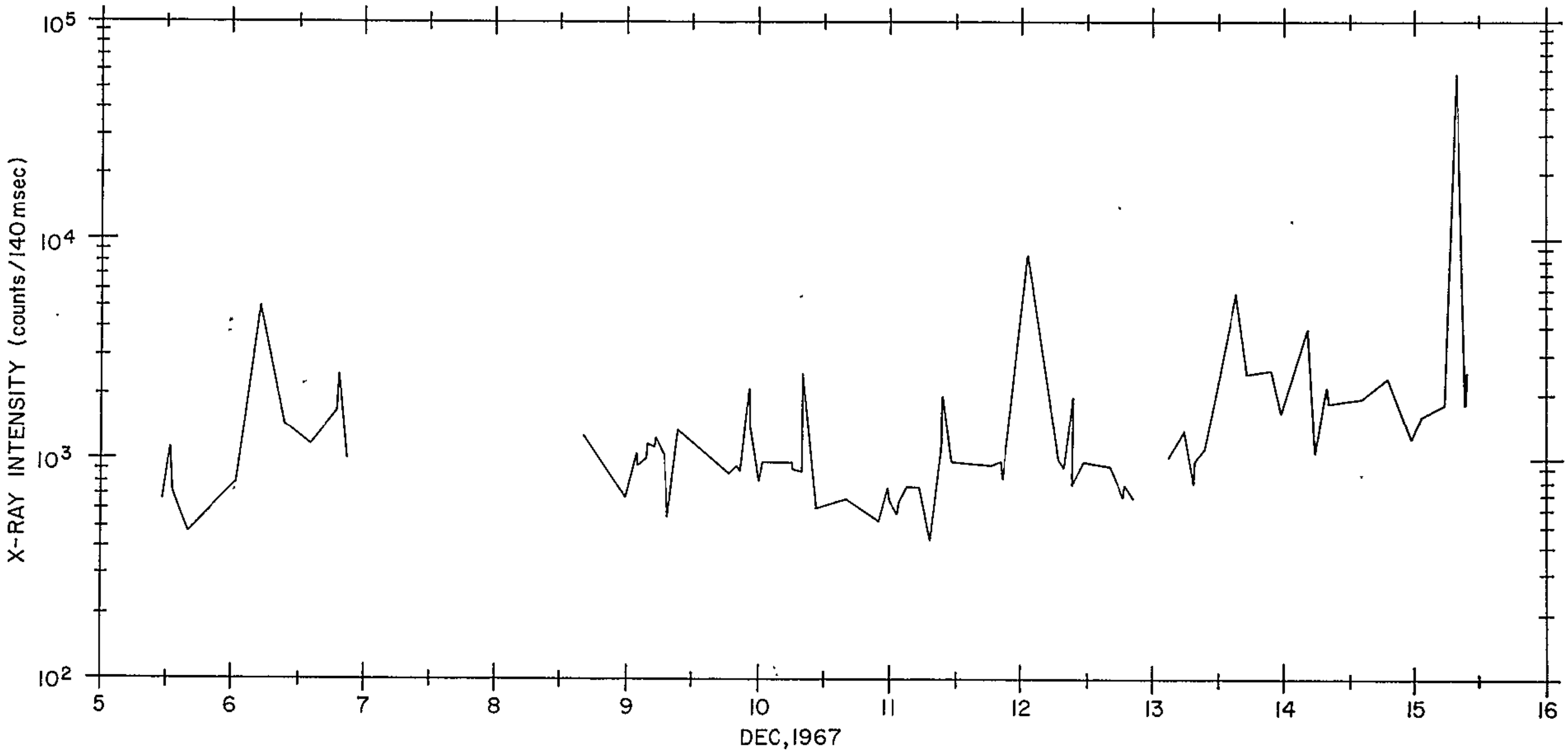


Figure 4-12. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9108.

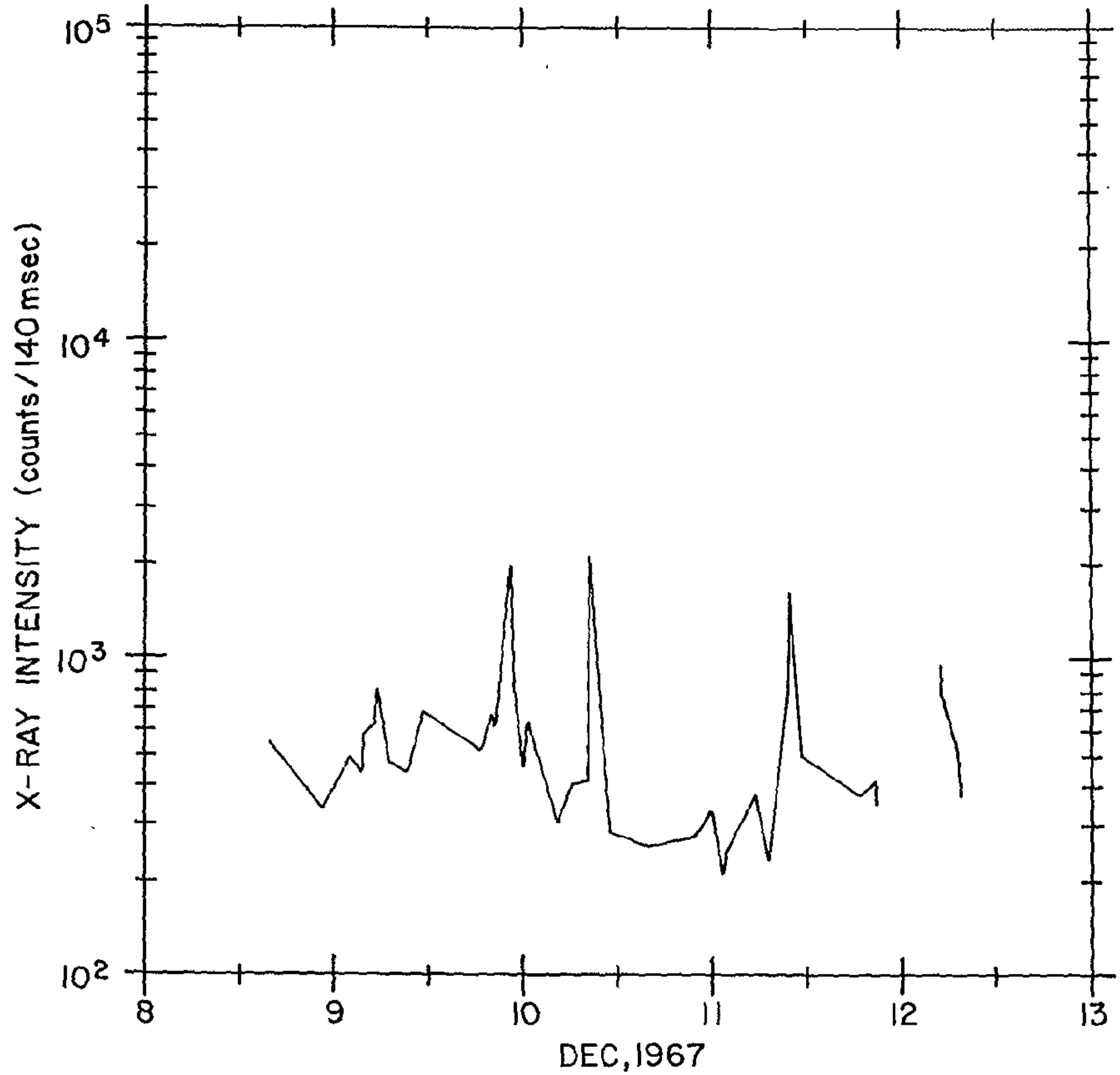


Figure 4-13. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9110.

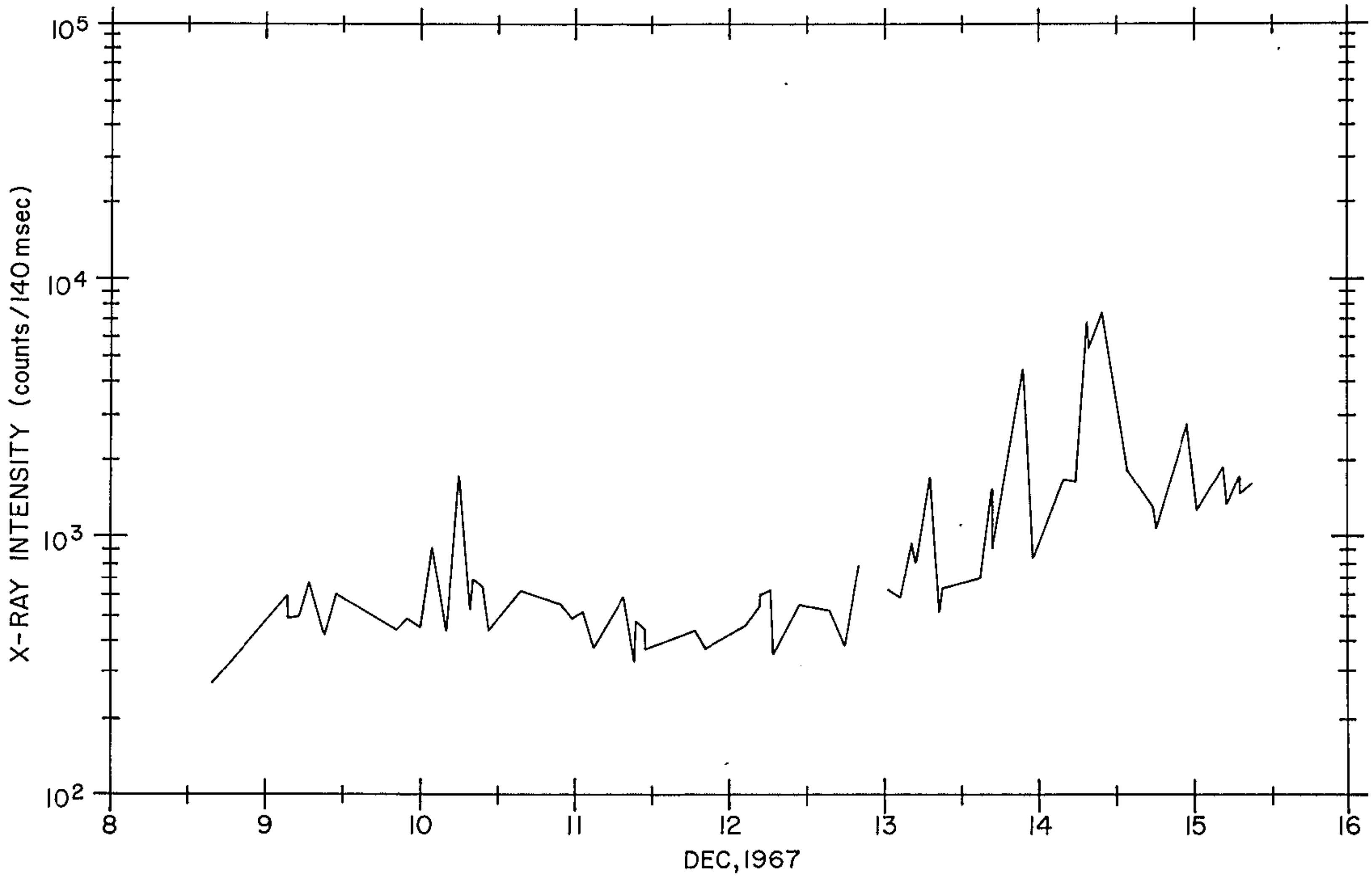


Figure 4-14. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9115.

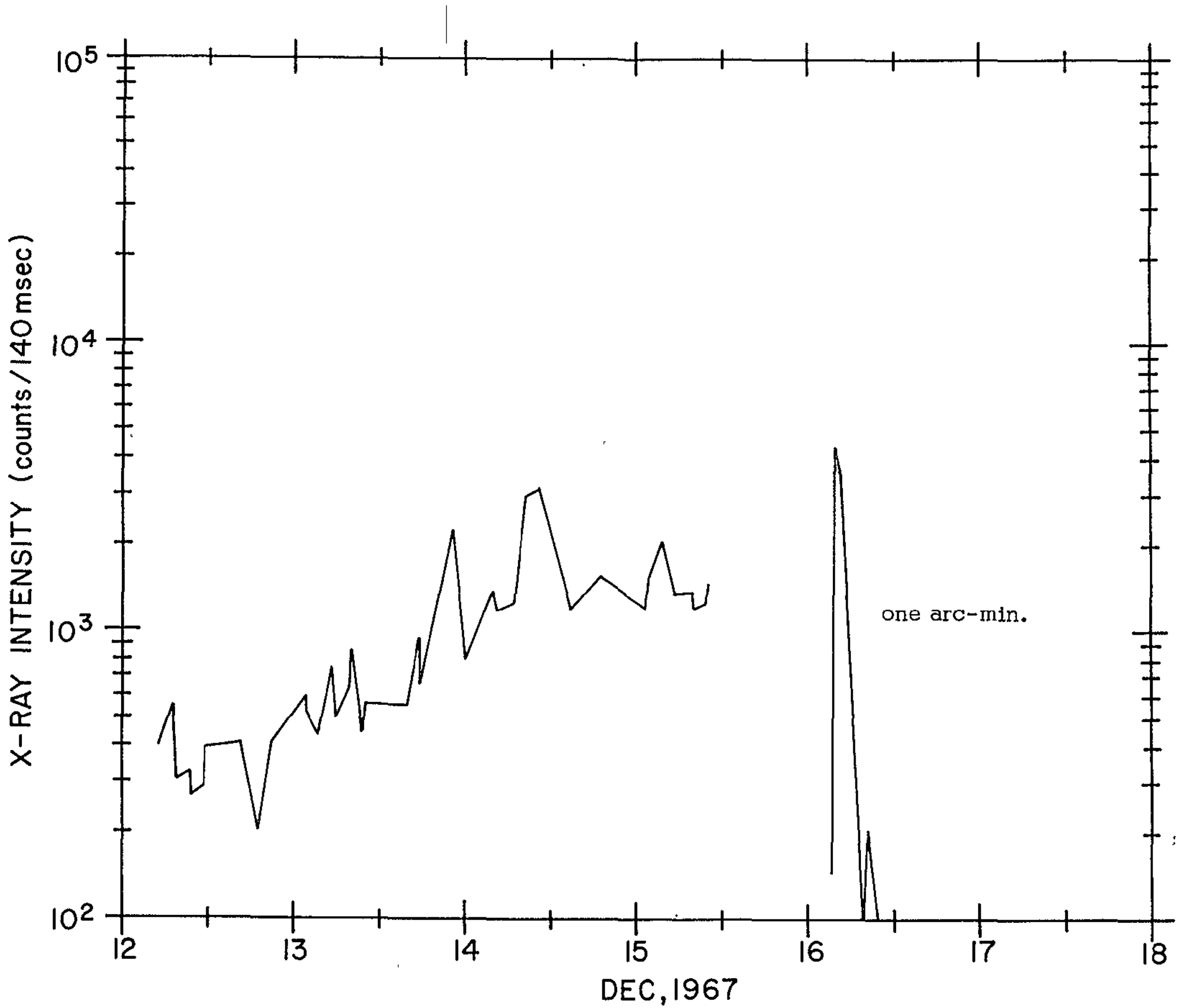


Figure 4-15. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9118.

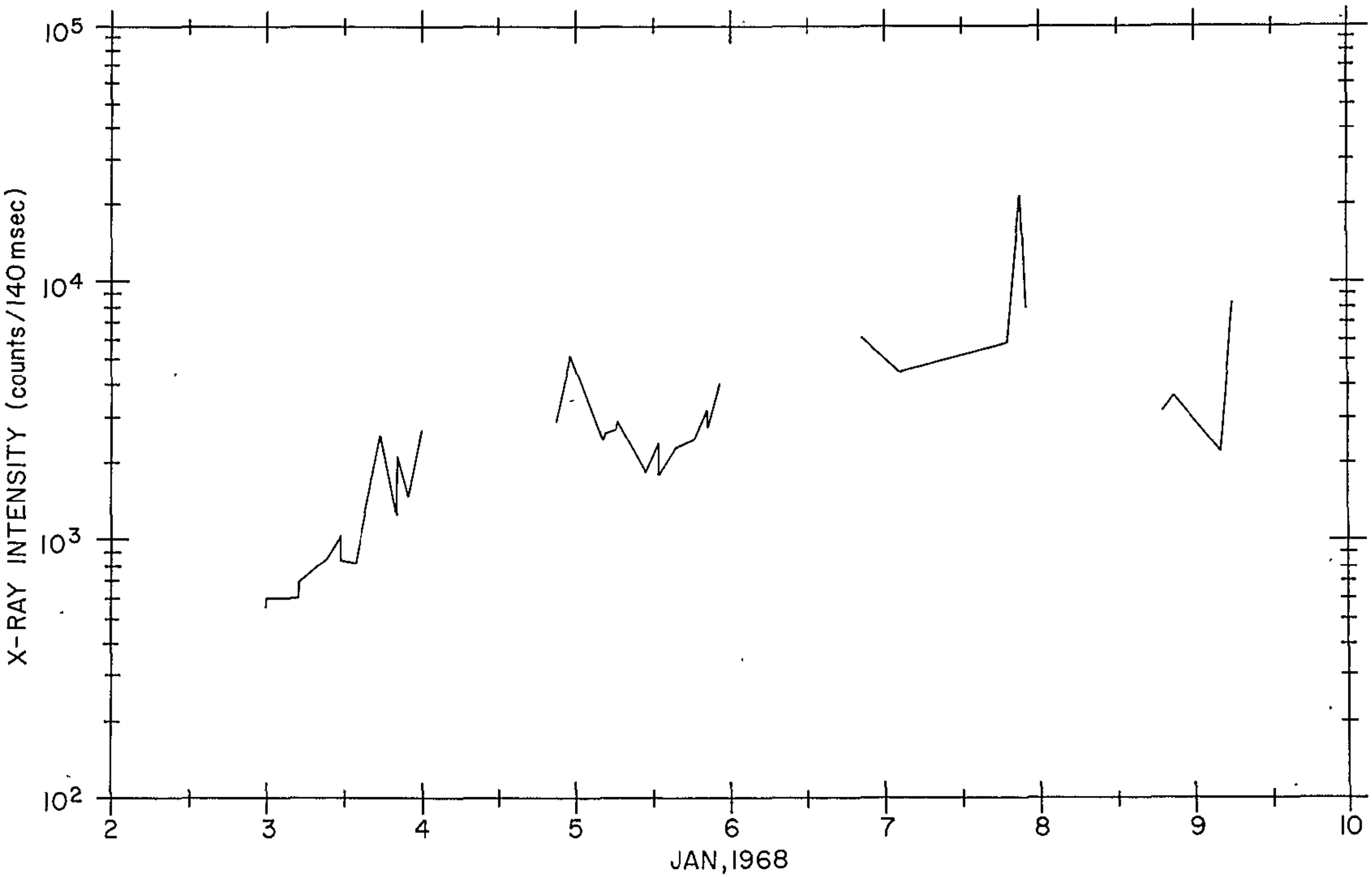


Figure 4-16A. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9146.

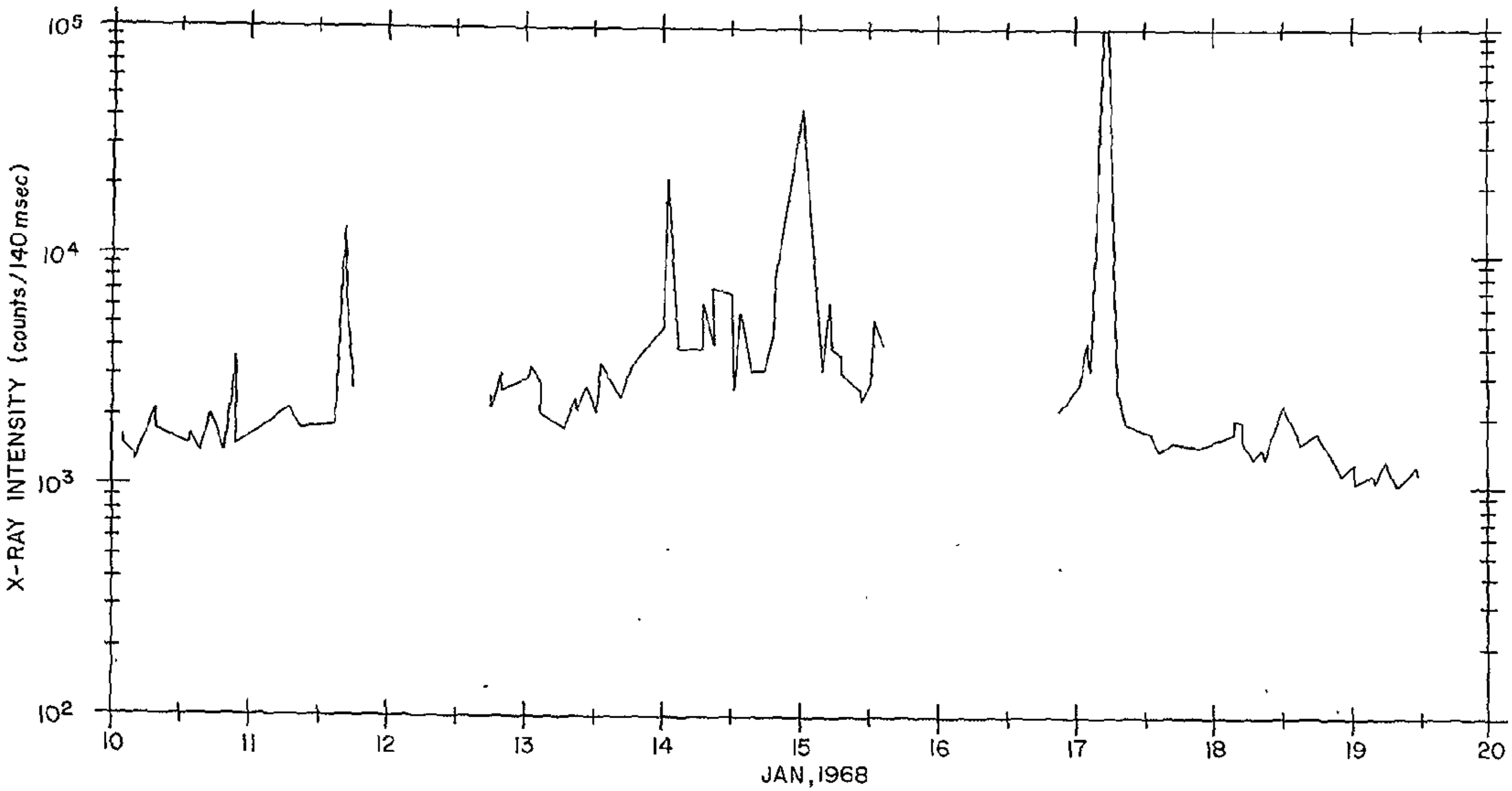


Figure 4-16B. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9146.

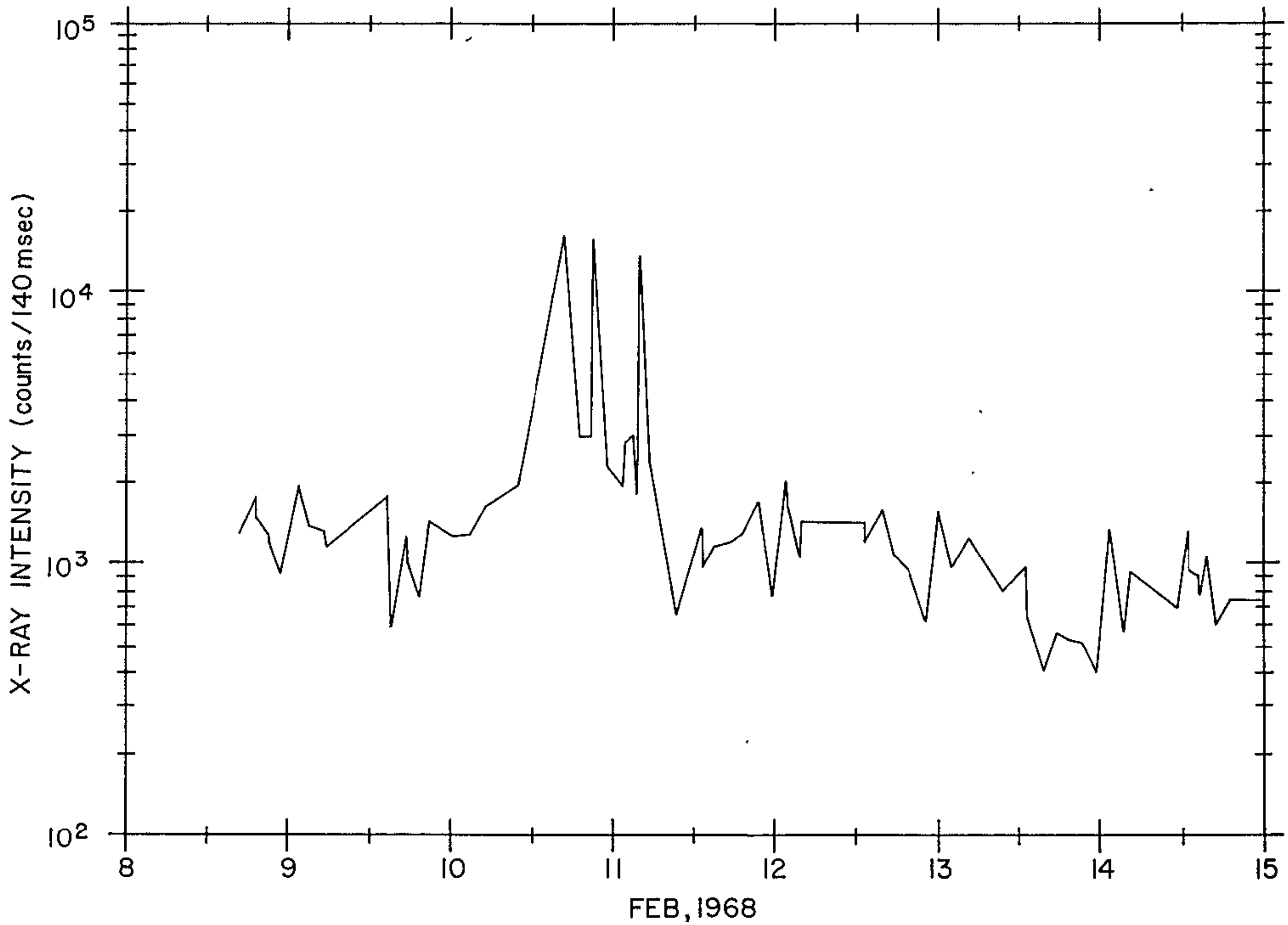


Figure 4-17A. Tracing of time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9204.

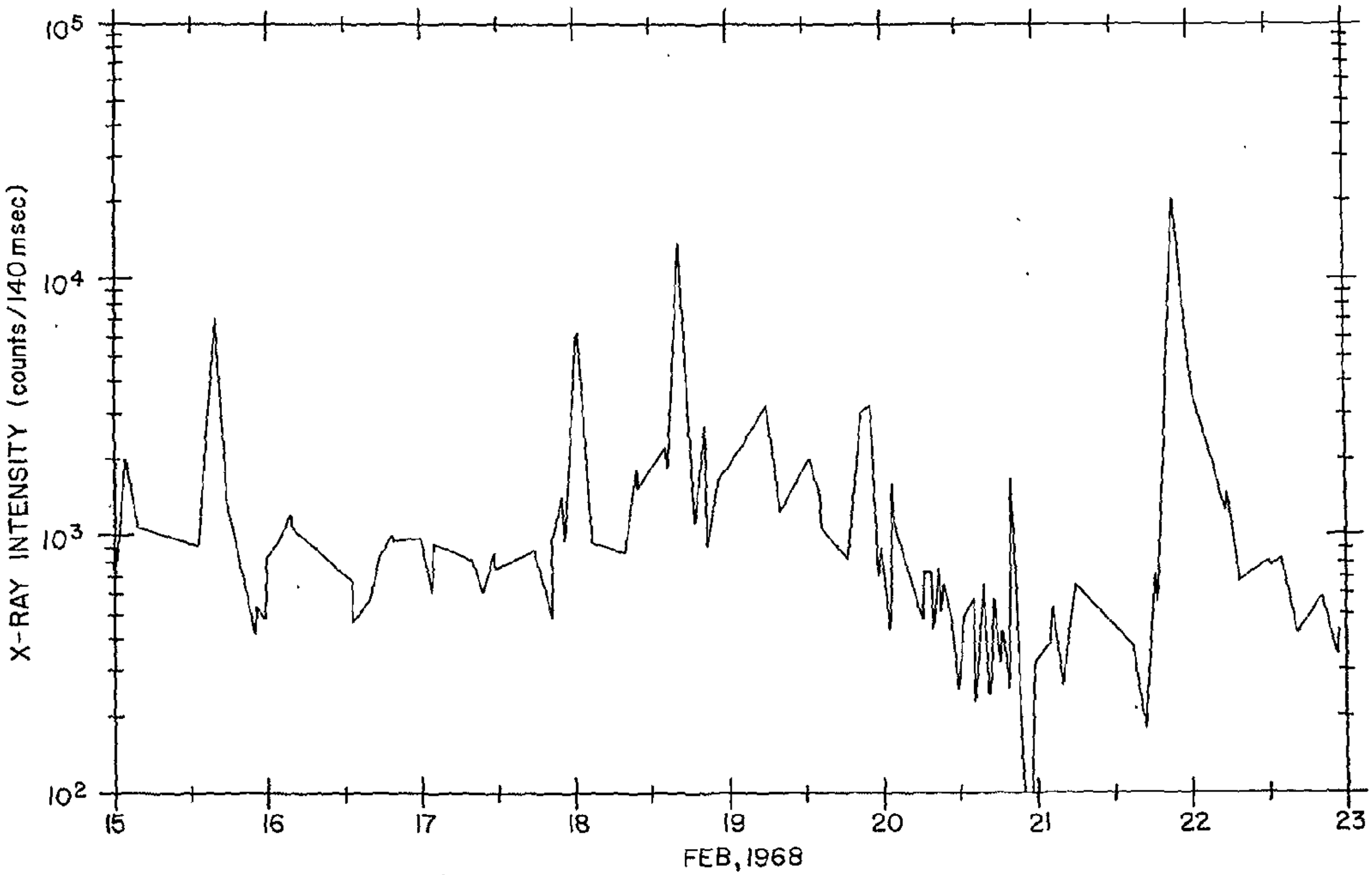


Figure 4-17B. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9204.

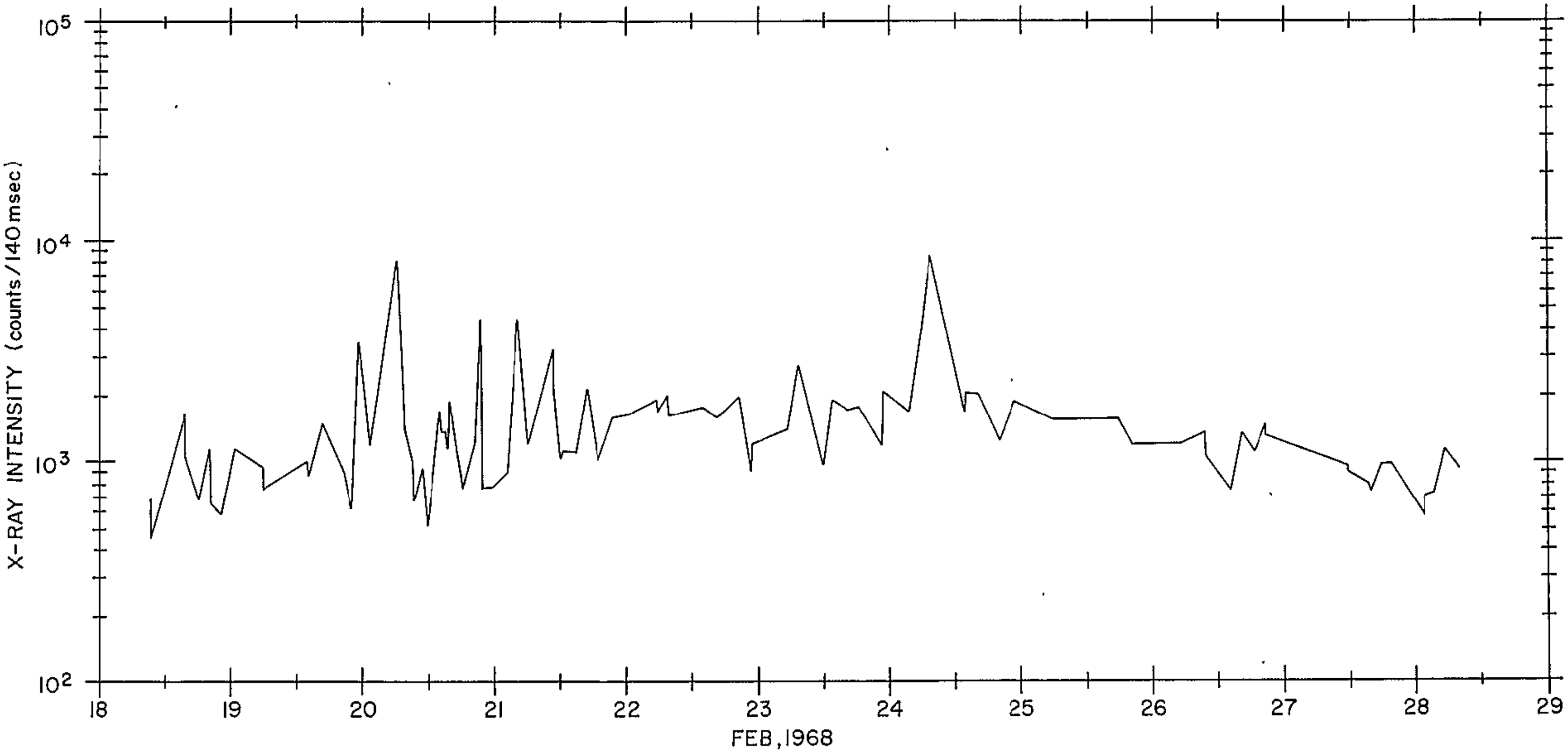


Figure 4-18. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9222.

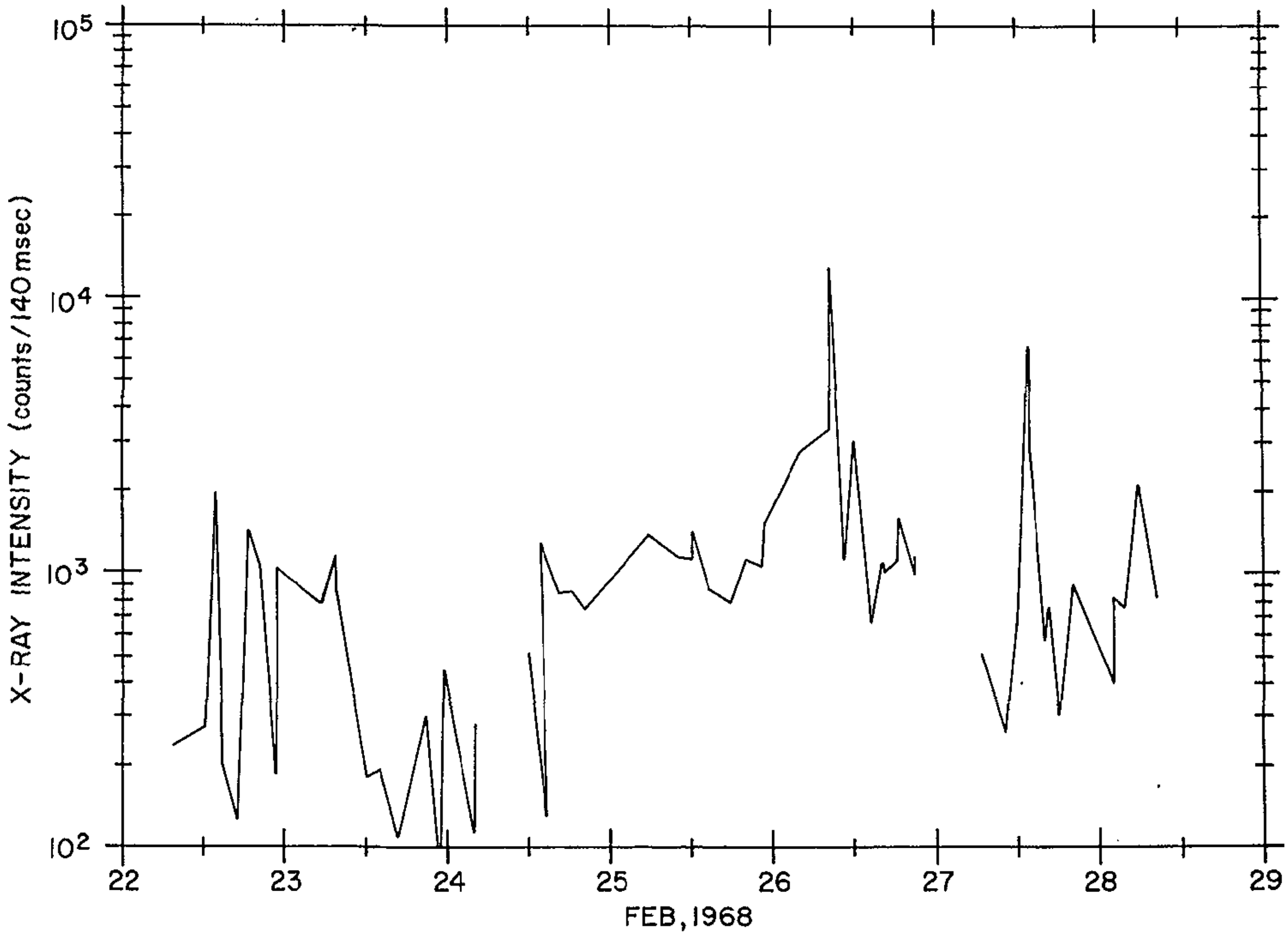


Figure 4-19. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9224.

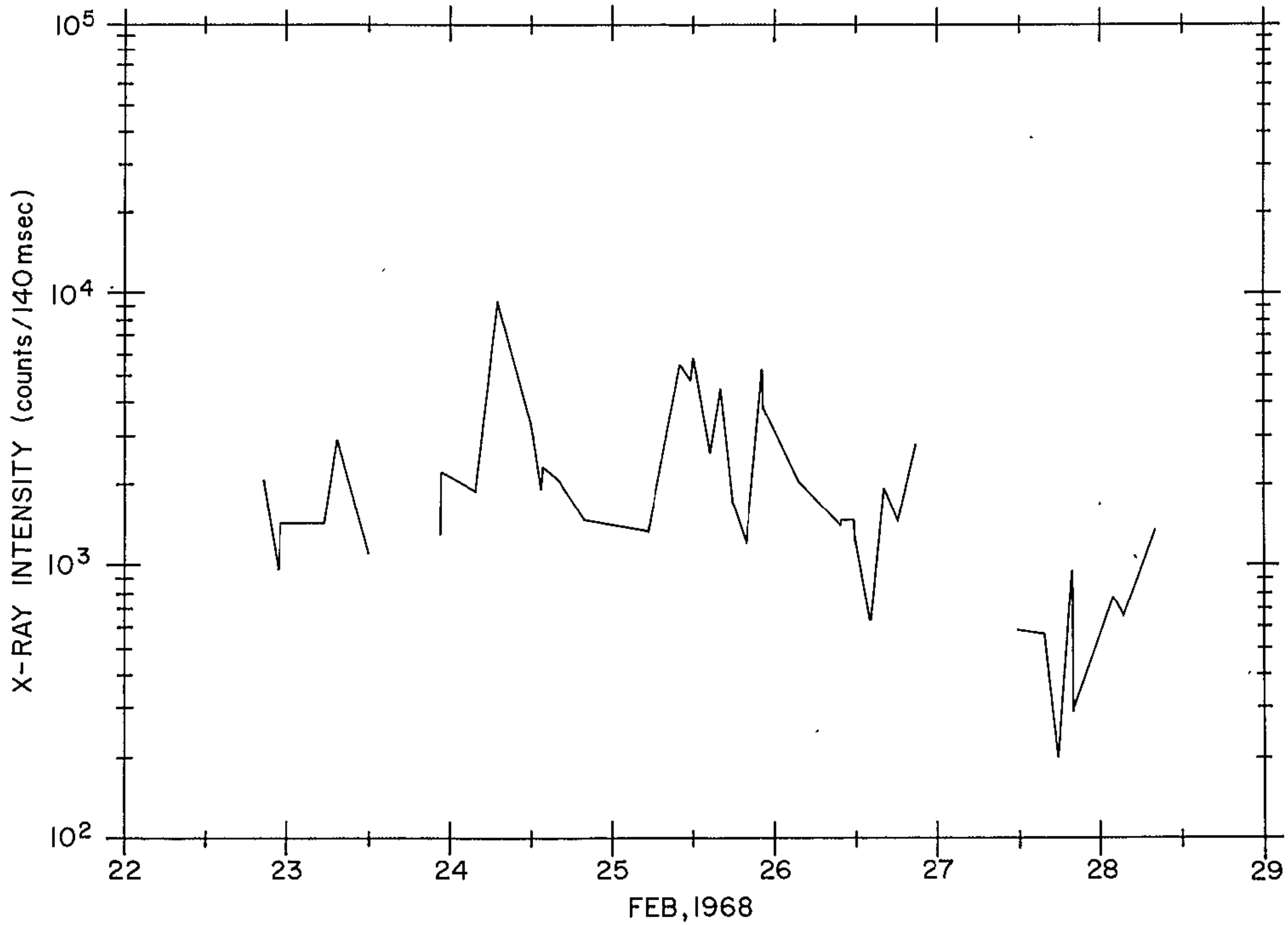


Figure 4-20. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9225.

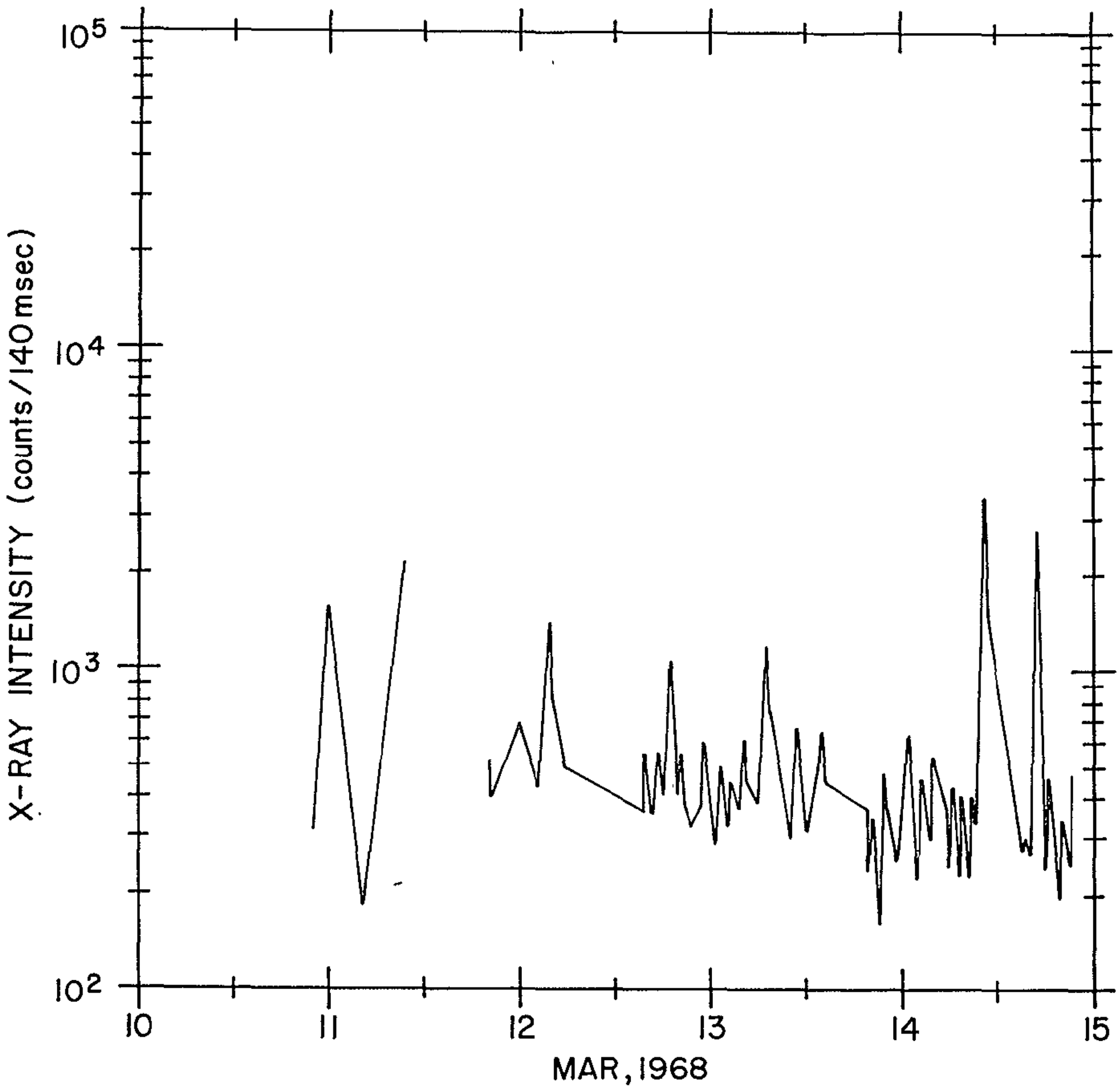


Figure 4-21A. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9267.

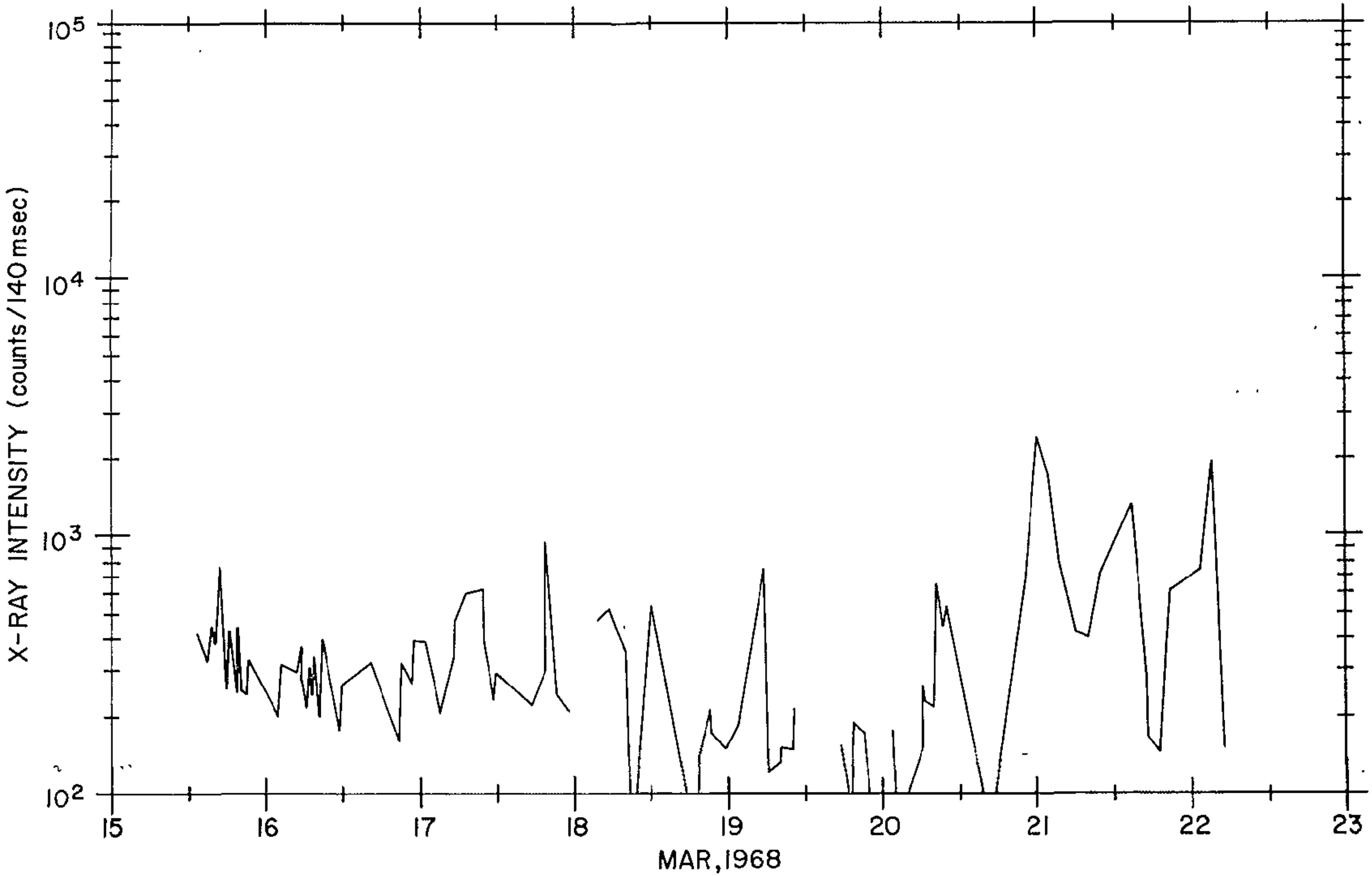


Figure 4-21B. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9267.

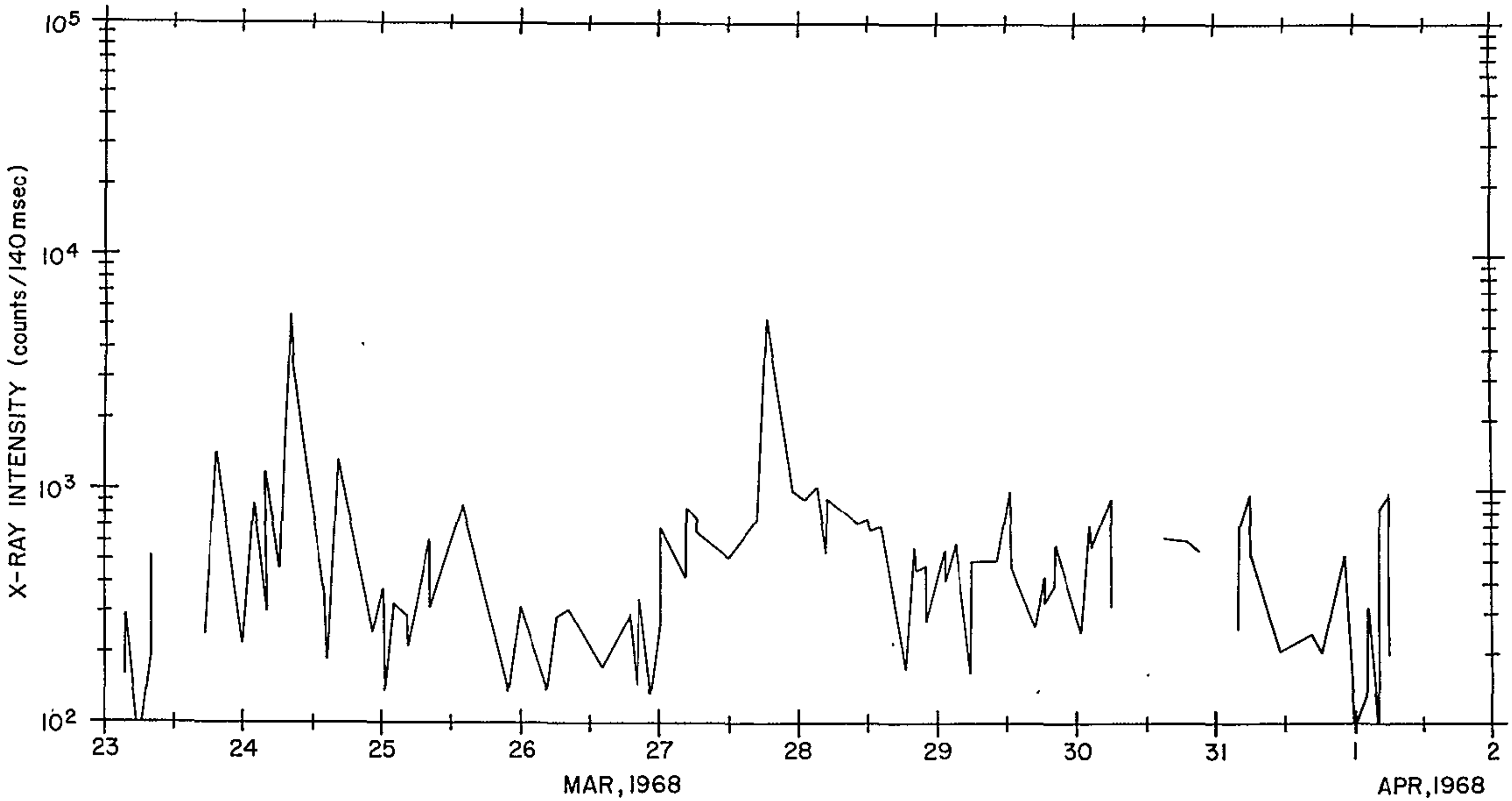


Figure 4-22. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9273.

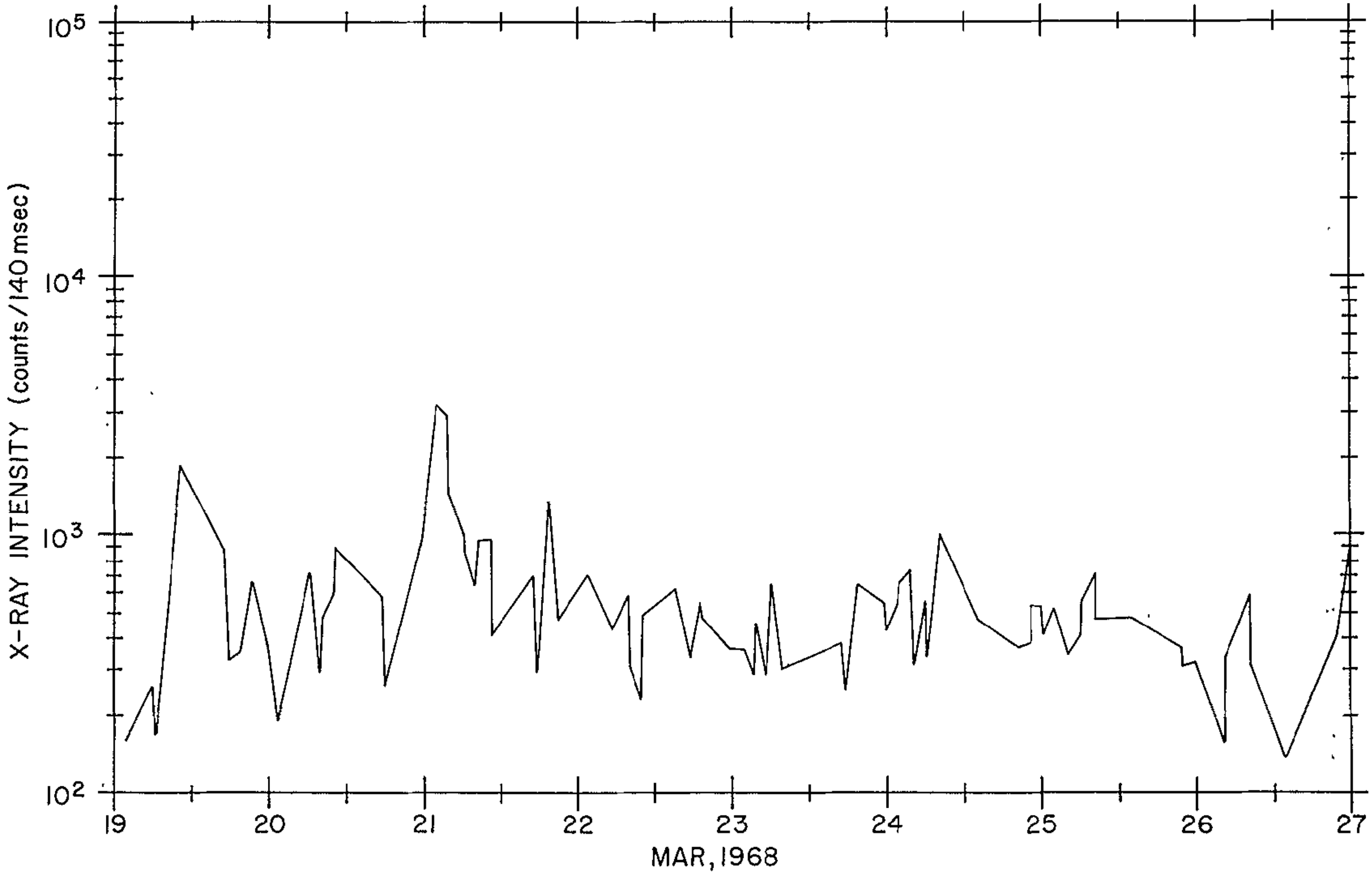


Figure 4-23A. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9285.

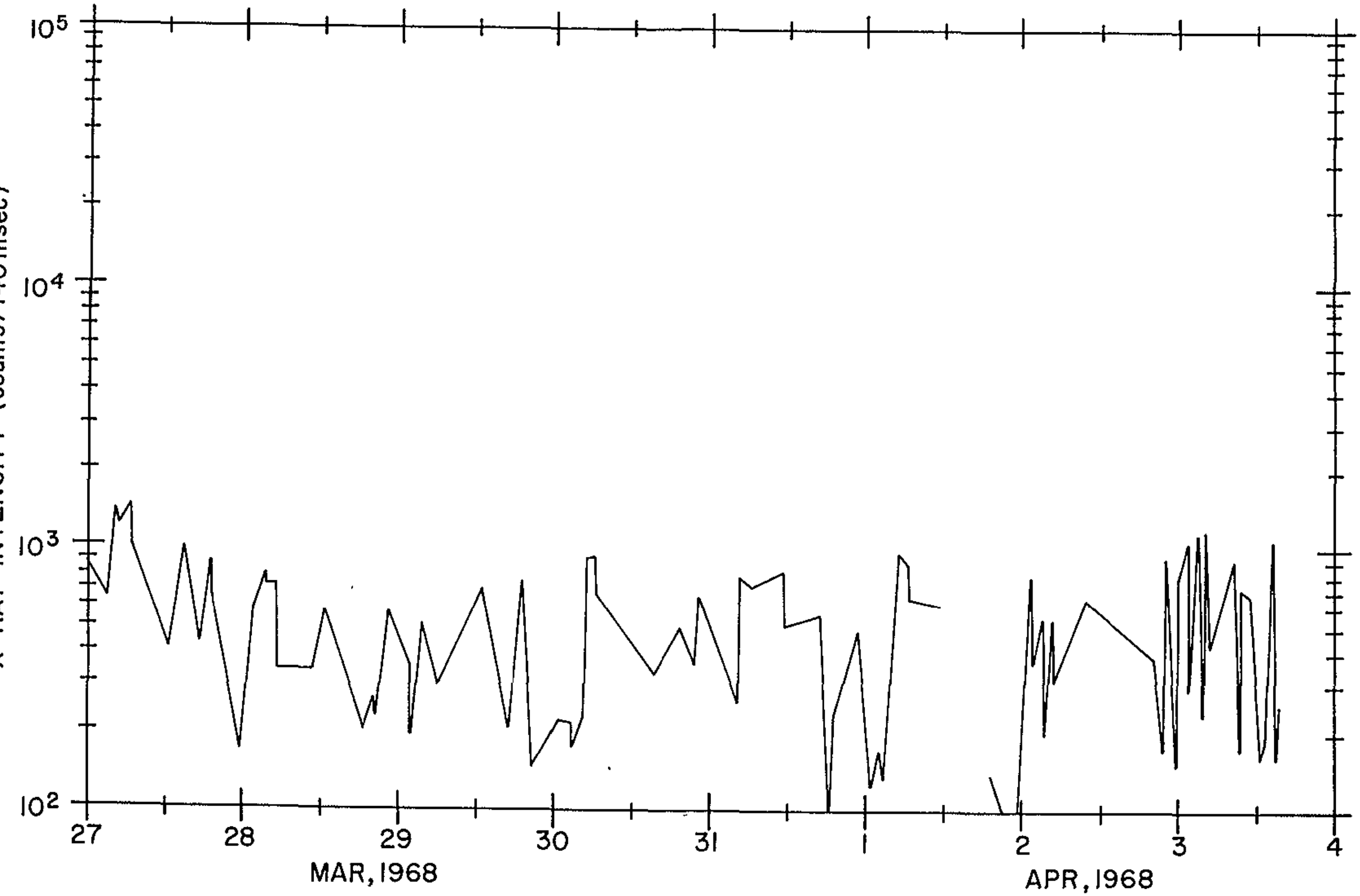


Figure 4-23B. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9285.

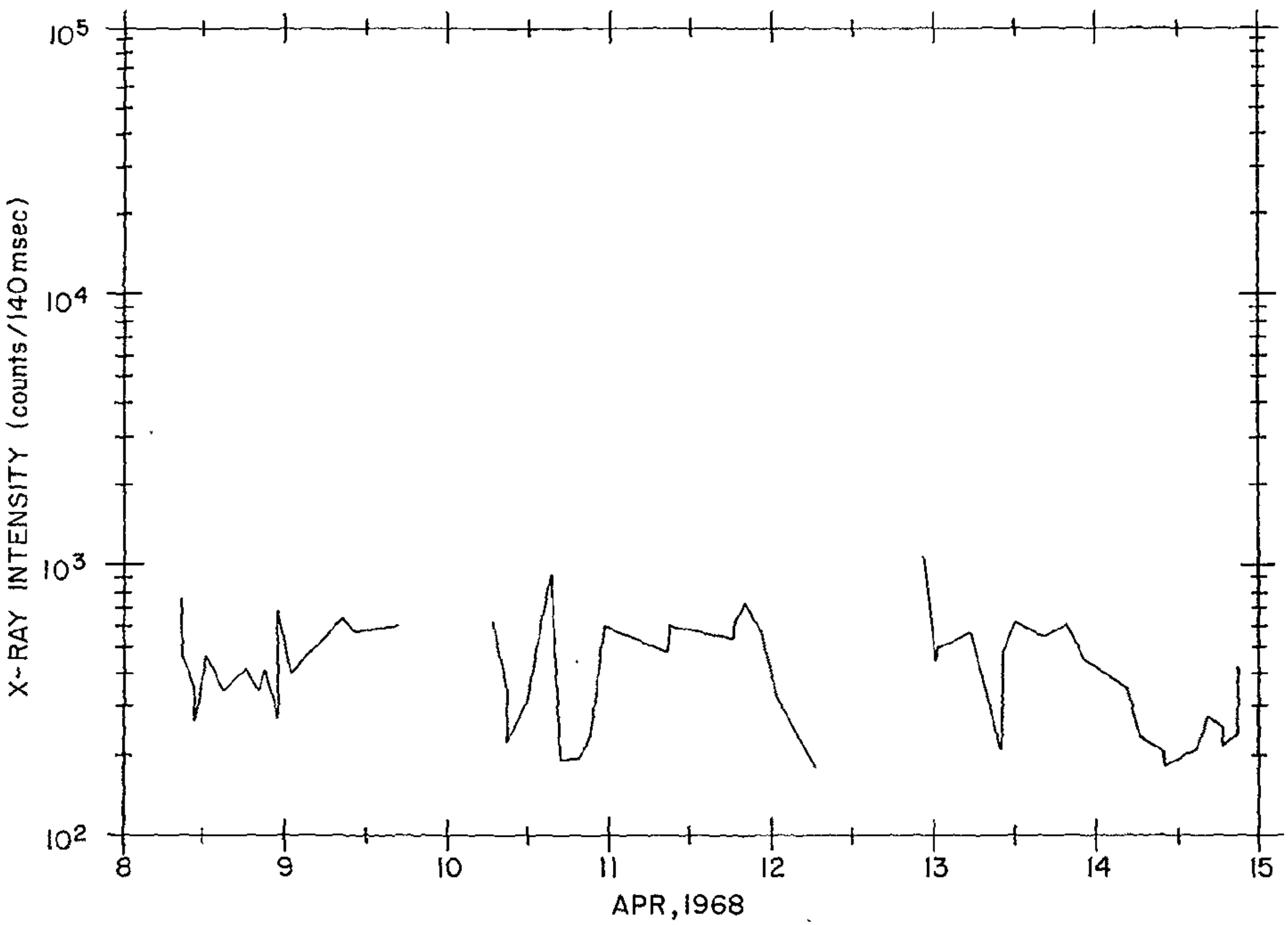


Figure 4-24A. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9313.

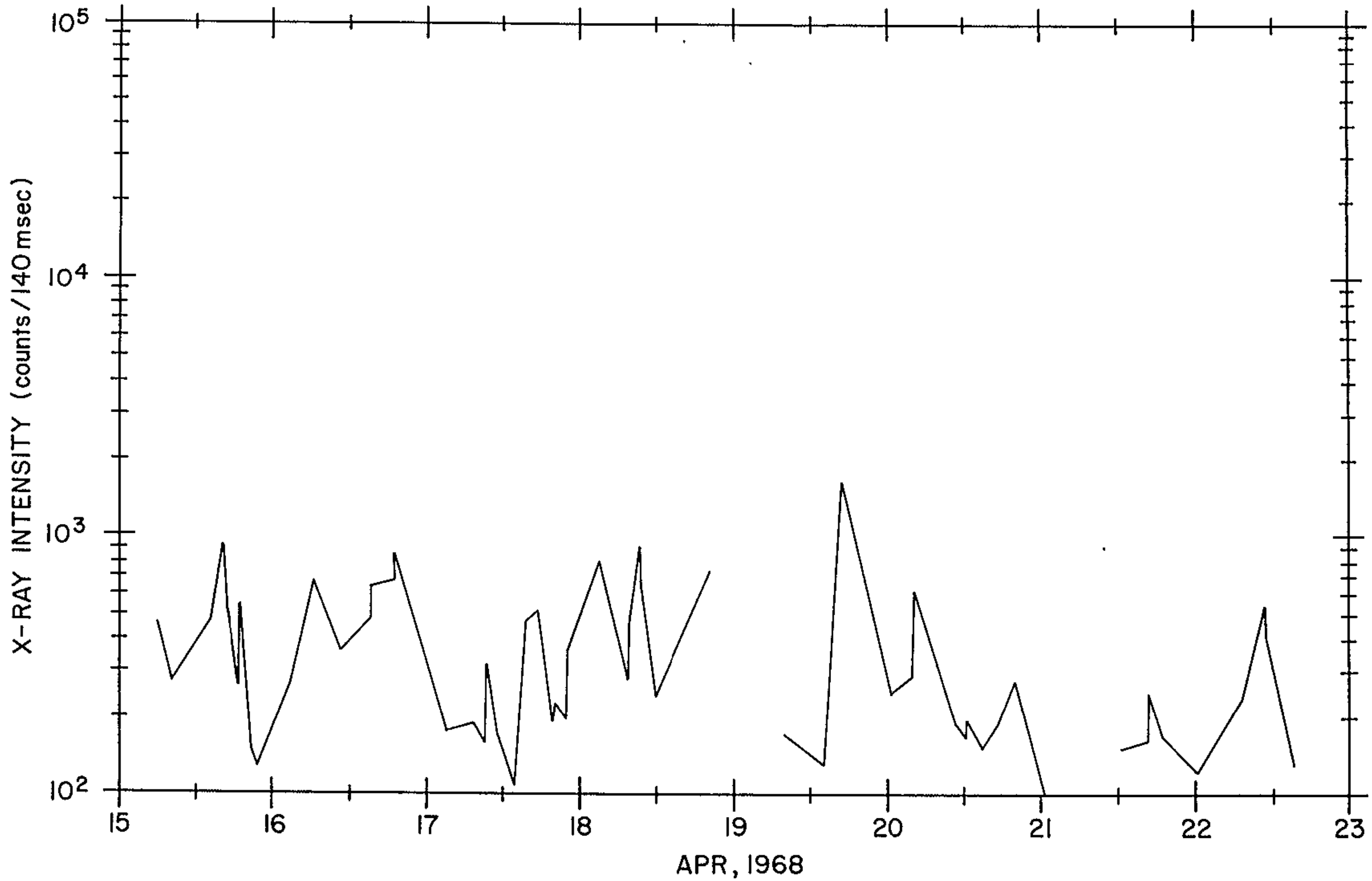


Figure 4-24B. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9313.

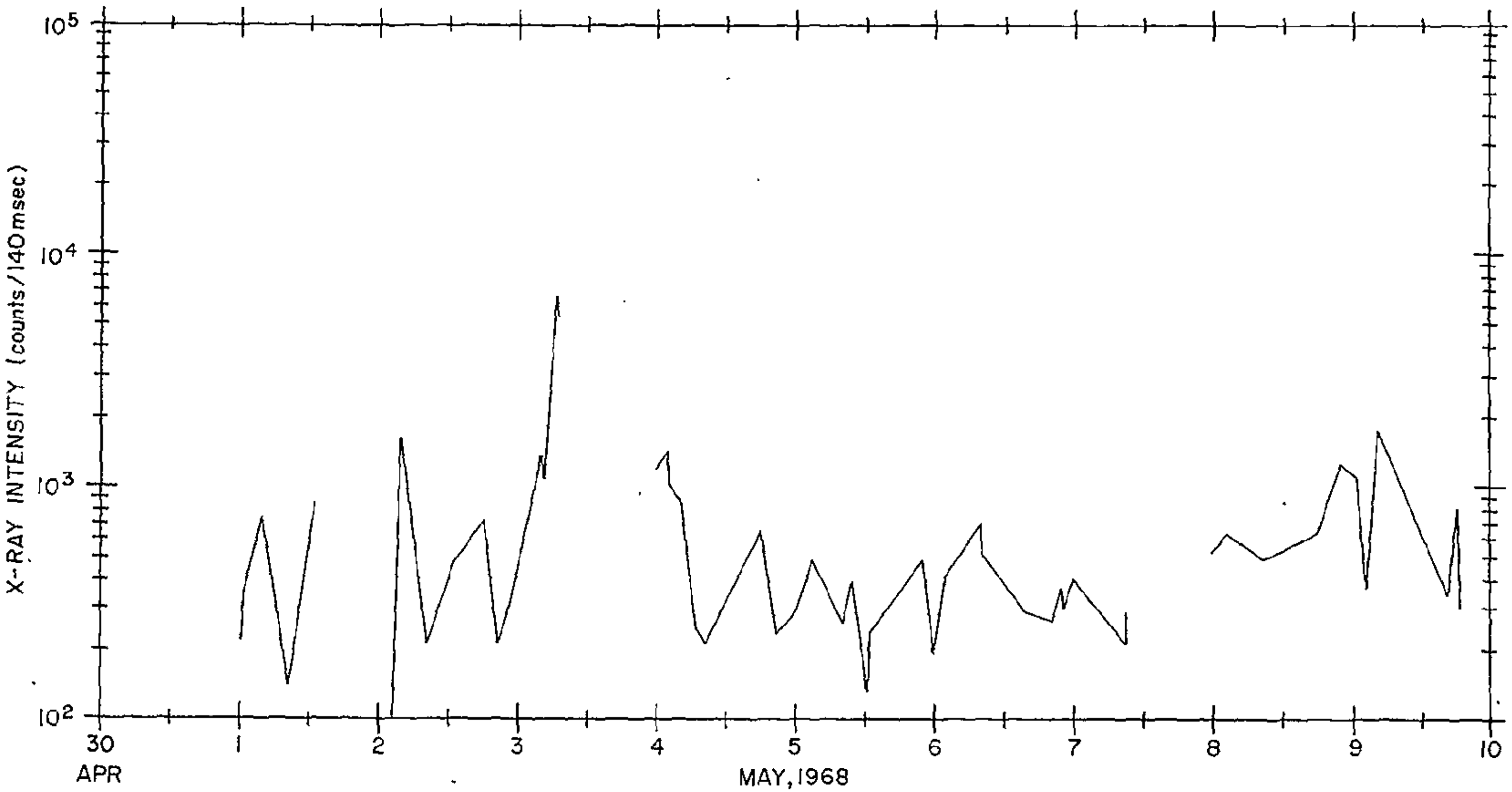


Figure 4-25. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9358.

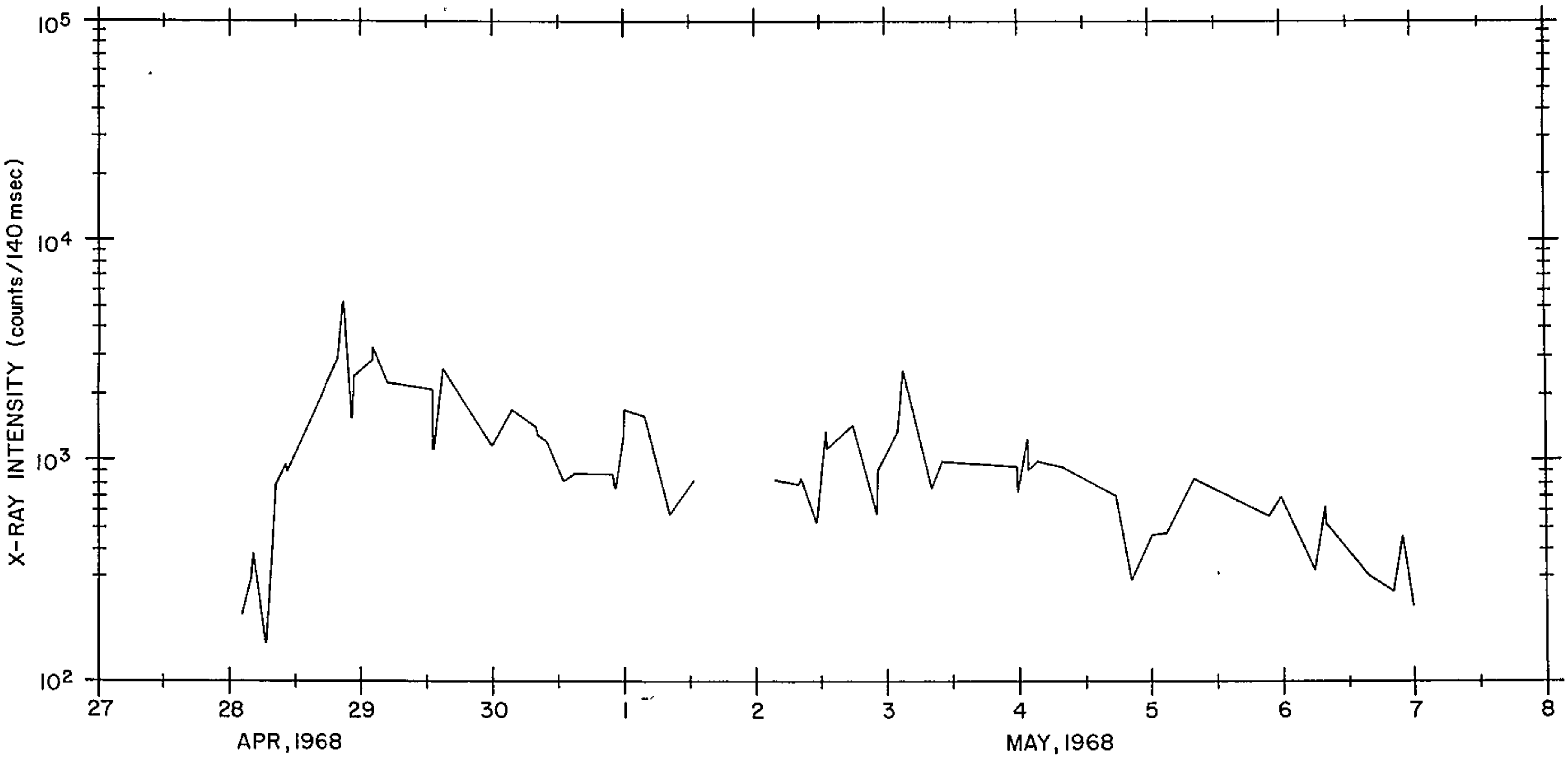


Figure 4-26. Tracing of the time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9364.

can be used within the time period of the raw raster tape. The ring integrations are performed in the same manner as discussed in the previous Section. The program prints out the input data and the same information as in the previous Section, with the exception that each raster scan will have a number of ring integrals listed under it.

This program is used to calculate flux values that can be directly compared with solar spectroheliograms published daily by the Radio Astronomy Institute of Stanford University.[17] The scans, taken between 2000 and 2100 UT, give radio brightness temperatures at about the same resolution as our data, and at a wavelength of 9.1 cm (see Figure 5-1). This analysis has been completed up to 12 February 1968 and the results are discussed in Section 5.0.

4.5 Average Raster Program

This program is useful for delineating the boundaries of emitting regions and improving the statistical precision of the data for faint active regions. The raw rasters obtained with a specific filter and aperture mode are summed over the particular period of interest. The counting rates for this sample are averaged and the corresponding background raster is subtracted point by point across the scan. The same rejection criteria as used in the background raster generation program (see Section 4.2.2), are utilized in this procedure. Rasters obtained in the South Atlantic Anomaly are listed with the input data and systematically removed from the sample by the program.

The print-out format is similar to that of the corrected raster generation program (see Section 4.2.3), except that 1.0 is added to the value of the average corrected counting rate to allow printing of fractional average count rates in logarithmic format.

Thus the output printed word represents

$$\log_2 (\overline{N}_i + 1.0) \tag{4.3}$$

The information generated by this program is stored on tape for future reference. The analysis is complete from 25 October to 26 November 1967.

4.6 Raster Orientation Program

This program calculates the projected angles, α and δ, which are used to determine the orientation of the solar x-ray disc on a raster. α is the projected angle between the solar north pole and the pole of the ecliptic plane, the projection plane being that of the raster. For any given date the magnitude of α can be determined from the formula:

$$\cos \alpha = \frac{\cos i}{\cos B_o} \tag{4.4}$$

where i = the constant angle, $7^o\ 15'$, between the solar and ecliptic poles, and

B_o = the heliographic latitude.

The sign of α is taken to be + between about 8 September to 6 March for any year, and - the rest of the year.

δ is the angle relating the pole of the spacecraft's spin axis with the solar north pole, as projected on the raster plane. The spin axis pole is always horizontally left of the center of the solar image on a raster. Angle δ is determined by combining angle α with the spacecraft roll angle at any particular time. This result must be subtracted from 270^o, the angle measured counterclockwise between the spacecraft spin axis pole and the north point of the raster plane. Figure 4-27 shows these relations clearly.

The necessary quantities for these calculations are taken from

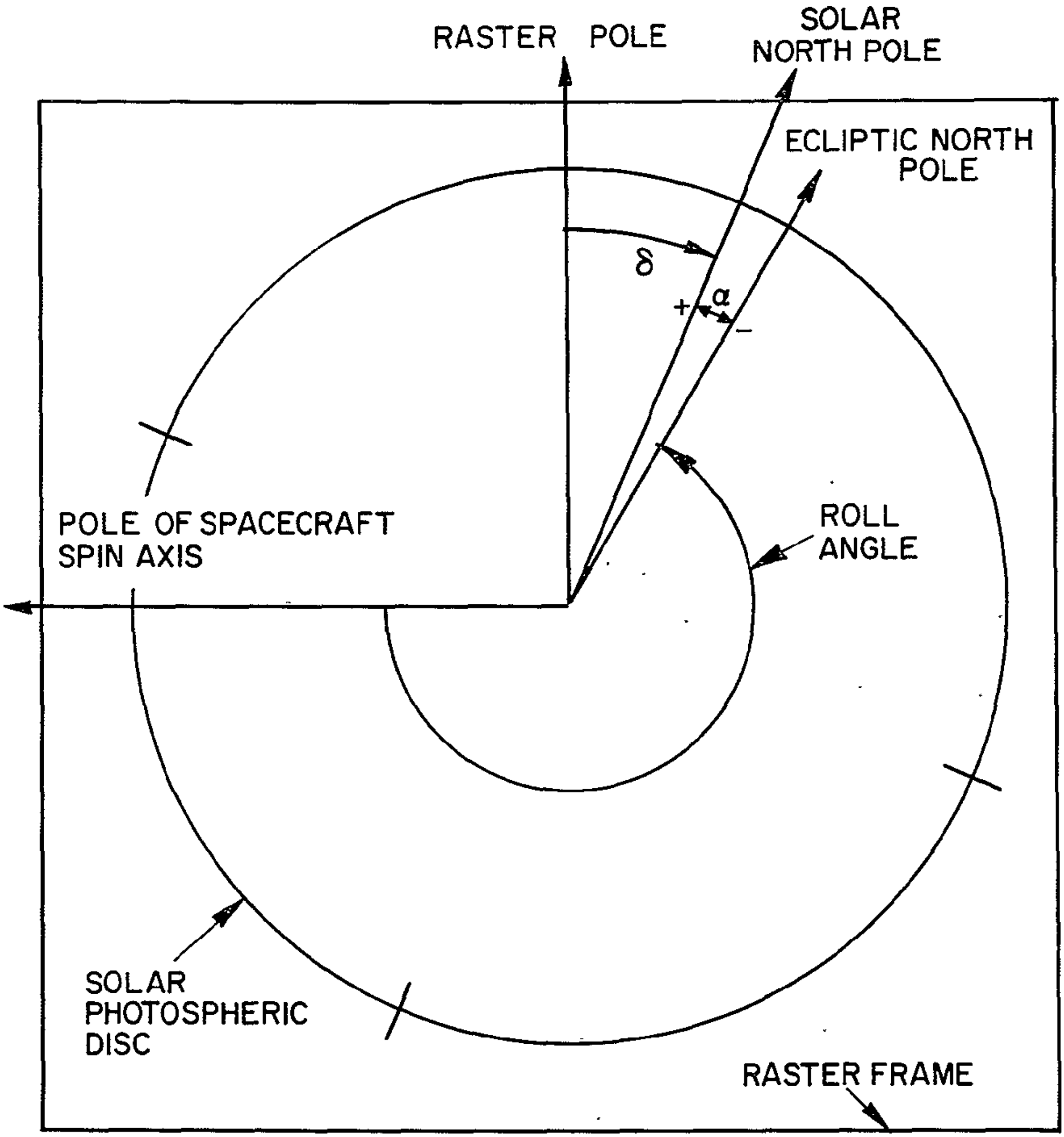


Figure 4-27. Raster format showing the relation of the orientation angles.

the appropriate A-E tape by the program, and the following A-E data is printed out: the spacecraft orbit number, the day number, the orbit start and end times (UT), the times of spacecraft entrance into and exit from sunlight, the spacecraft pitch and roll angles, and the computed angles α and δ. This program is essentially complete for the period covered by this report. Thus for any raster scan, the position of the solar north pole can be quickly located, knowing the angle δ and the exact center of the solar image on the raster. The exact center of the solar image is displaced 0.6 arc-minutes to the right and 0.4 arc-minutes up from the raster center.

4.7 Contour Plotting Program

Techniques for producing smooth contours of the OSO-IV filtergram data have been pursued. A typical contour map is shown in the center of Figure 5-1. This plot was produced by hand from an averaged filtergram of 3 corrected rasters obtained on 25 October 1967 in the 0.0005 inch Beryllium, 4 arc-minute aperture mode. An outline of the solar photospheric disc is superimposed on the x-ray map. The contour lines result from smoothing counting rates from adjacent words around areas of similar intensity. The values associated with given contour intervals represent true corrected decimal counting rates.

We expect to produce such a contour map for each day from 25 October 1967 to 12 May 1968 by use of a computer program, to be written in the next phase of data reduction. The OSO-IV x-ray data for this period then can be directly compared with that of other experimenters.

4.8 Noise Suppression Criteria

Various forms of data rejection criteria were discussed in Section 4.2.2. The problem of noise and the methods used for suppressing it on the output filtergrams are discussed in this Section.

The Van Allen Belt of energetic charged particles dips far into the ionosphere over the South Atlantic Ocean to produce the South Atlantic Anomaly. The spacecraft's orbit intersects this extensive particle cloud several times a day. During these passes when our instrument is operating, the detector is saturated regardless of its mode of operation. Thus, these rasters are easily identifiable by their high counting rates, and can be readily eliminated from the sample. Figure 4-28 shows a typical corrected raster scan obtained when the spacecraft is just entering the Anomaly.

The following methods are used to eliminate South Atlantic Anomaly rasters. In the background raster program, (Section 4.2.2), if the average count per word in the first 20 columns of a raster exceeds 5 that scan is removed. In the raster averaging program (Section 4.5), a raster is rejected if the sum of the scan columns 10, 20, 30, and 40 exceeds 4000. This same criteria is used to identify South Atlantic Anomaly rasters in the ring integration routines (Section 4.4), but the rasters are processed normally with the words "Van A. Raster" printed out beside the counting rate. This is done to avoid the possibility of accidentally excluding flares with this criteria.

During several orbits per day, raster noise appears abnormally high. These noise counts, along with the more usual random noise counts, are eliminated by the criteria discussed in Section 4.2.2.

Analysis has indicated that the wavelength response functions shown in Figure 3-1 lead to anomalously high short wavelength x-ray fluxes in comparison with the results of other observers. The most likely explanation for this discrepancy is a decrease

```
CORRECTED RASTER SCAN STARTING AT UT  FEB  16, 1968   UT TIME  8 48 52.12
01 1/2 MIL BERYLLIUM           LAMBDA 1 =  2.00    LAMBDA 2= 13.00     KN =12610.69
00 40 MIL APERTURE             EPSILON =    .10          N BAR CAL =     .46

    01      05        10        15        20        25        30        35        40
48  --------------------18------11------17212411----36172420283634283037424041424441  48
    ------------------------21--------1224--1621242630283337373639373841423038464442
    --31--------12--17--------11--20--11--2420--2633--242620263440413438404242484646
45  ----------------------11----------1620111611282024322330383938393334414541474240  45
    ------------------121113------16111011282030122824152620353934373339444145364642
    ------------17--11------------1116--16102611--1026333632383033394340304241514443
    ------------17----------17----------11111711211532352828343939343837383942424746
    ----------------1711--11------------26172320--2423263028303633343540444439414744
40  ------------------17--1220----1012--20--2423203532343826283435203638344241443843  40
    ----------------24--1716------16--16--231624161123263633313341343337364142414345
    ------------------1211--1611----------17----203016203232423034423942344041354646
    --------------------16--16111611----26151616372028233015373632374134384141464847
    ----------------21--11171112201011202020--23351616303037273629253441403943364244
35  --------------------1011--111111--111623--10282028322623353833343541384547414840  35
    ----------------17--17----11--10112011162626202830261928383837183433403844383643
    --------------------------1611162420--302628203019302325333334374046443939454746
    ----------------------16----------11--161915202626263032232834413841442741464644
    ----------------------112117--16172616--2828--1531202339413319374139324141464345
30  ------------------------20----231120----2415282319282933333038384139423247324338  30
    ----------------------------17--101612--1630242632323238284136423536304039444536
    ----------------------24----1111------202011152626233425304132313929394544384742
    ----------------------21------261020--23----163030283034322238333736374036394446
    ----------------------------1116--2411--2315--2828--3229363538314042393846464247
25  ----------------------------11201111--1615--342019233237343727323735453641474449  25
    ----------------11------16----------243220192030--333038293132373238311641433941
    ----------------------16------16162020163028202334362629333541343941414442374643
    ------------------------24----17--10--20--30231523342523313525333543454242424644
    --------------------------1111--11--11112026152835282525343135404237394342434645
20  ----------------11----------16----------2310162015263525294038394035403243444440  20
    ----------------------1613--2111----32--2815102826303532273136434443394141354143
    ------12------------------11------11--3028--163020333823313537363937433846334341
    ------13--------------12--------1124----1626162423253240273735344136374342415051
    ----------------------------1720212412162428261630303433274229384438464645274444
15  ----------------11----------------162424--24262428283736223327384141434247413648  15
    --------------17----17----------1316172826--281723333627313338293941434038434041
    ------------------------11----21--17--2626--262823332619283839353627414342374144
    ----------------------17------------21242828112311322328343222403732424046423944
    ----------------06------------------17162121172821332319343136343538453646434648
10  ----------------------11----12----------2426242626353023353829403938404343334149  10
    ------------------------------------20111220283026262832393429343239404242415046
    --------------------12--------1721----242429163537283833303135343538434738354543
    ----------------------------------2421162617161626333036283725464041454349414942
    ------------------------18--------1711111220262828203532323927313740404343434642
05  --------------------------13------11--252617282426282036303631384342393743494642  05
    08----------------------18--------1313--1727292621262638363038343738443838433639
    08--------------------------06------12182112202829332830413534403840414424414651
    08--------------------0612--182206------2721272417362833373238374037424742434542
01  08----------------------------17--13131730--173521303433402830372841333443434144  01

    01      05        10        15        20        25        30        35        40
```

Figure 4-28 Typical corrected raster obtained when the spacecraft was just entering the South Atlantic Anomaly.

in orbit of the long-wavelength response function of the detector photocathode. Recalculations of the response functions have been made in order to compensate for this apparent loss in long-wavelength efficiency.

5.0 SCIENTIFIC DATA ANALYSIS

5.1 General

The OSO-IV x-ray telescope experiment was the first instrument with the capability of identifying the sources of solar soft x-ray emission, and of monitoring individual sources for periods on the order of the lifetime of the source. As a result, the instrument provided a unique source of information on the x-ray activity of solar active regions during the time period covered by this report.

The analysis of the OSO-IV telescope results has followed three main lines. First, the angular resolution characteristics of the instrument have been used to determine the spatial dimensions of x-ray emitting regions. Second, time histories of the x-ray activity of individual, selected active regions have been studied in order to determine the characteristics of the time behavior of these regions. Third, the data has been compared with observations made at radio and optical wavelengths. The results of this analysis are contained in this Section.

5.2 Location and Size of X-ray Emitting Regions

5.2.1 <u>X-ray Emitting Regions</u>

A typical raster scan of the sun (Figure 5-1) shows eight distinct regions as sources of solar x-ray emission. The 9.1 cm and CaK spectroheliograms of the same date are presented for comparison. As was originally noted by Chubb, et al.,[16] the x-ray emitting regions are associated with solar active regions. Therefore, the x-ray brightness of the coronal limb in the instrumental passband is less than 150 photons/cm^2-sec-(arc-min)^2.

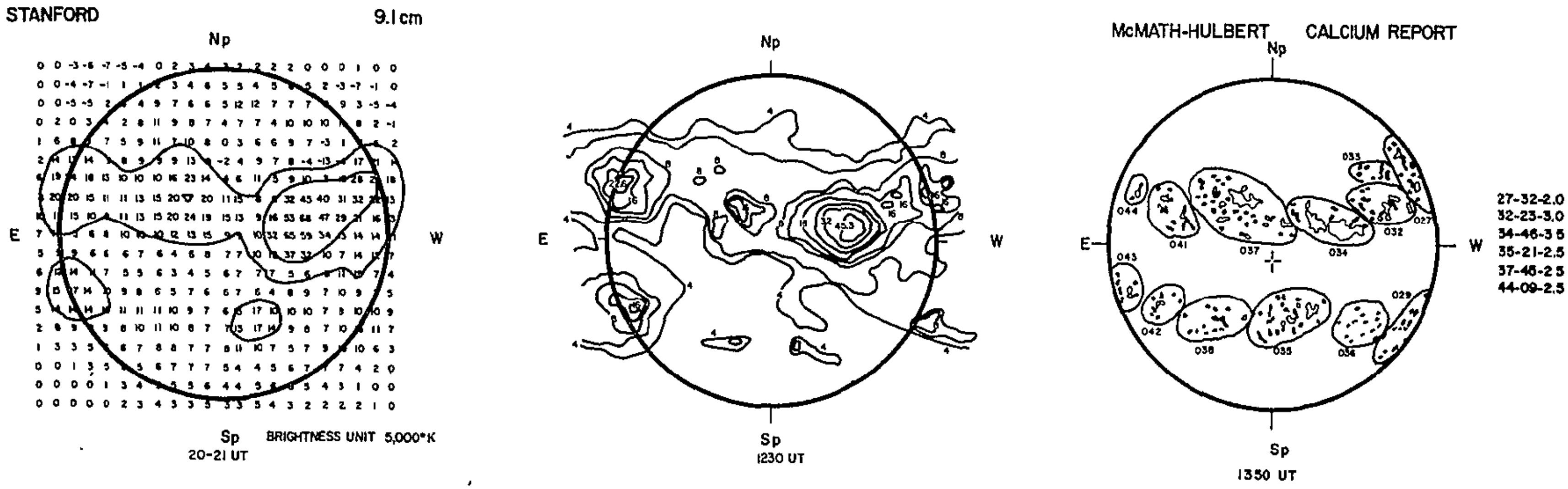


Figure 5-1. An x-ray contour map of the sun produced 25 October 1967 by the OSO-IV x-ray telescope experiment. Also shown are 9.1 cm and CaK maps for the same date.

There is a substantial range in the x-ray emission of individual active regions. The total photon flux observed from region 9034, the brightest region shown in Figure 5-1, is $(4.6 \pm .2) \times 10^4$ photons/cm^2-sec. The flux observed from region 9035 is only $(3.8 \pm .8) \times 10^3$ photons/cm^2-sec. Thus the range in x-ray flux in the detector passband is at least a factor of 12. Moreover, several of the active regions observed in CaK are below the threshold of sensitivity of the x-ray experiment at this time (approximately 2×10^3 photons/cm^2-sec). The physical conditions in the various active regions must differ for this to be the case. The ratio of the areas observed in CaK for regions 9034 and 9035 is only 2.2[17]; therefore unless the vertical structures of these active regions are very different, either the temperatures or densities of the x-ray emitting portions of these two active regions must be different.

5.2.2 Vertical Extent of Active Regions

Recent high resolution solar x-ray images[8,9] obtained with a rocket-borne telescope indicate that the x-ray emitting regions extend to substantial heights in the corona. The resolution of the OSO-IV telescope is insufficient for a direct measurement of the vertical extent of an active region. However, the vertical extent of an active region can be estimated by observing the time at which the region becomes completely occulted by the solar limb due to rotation. The vertical extent is then calculated geometrically. In general, the time at which the x-ray intensity from the active region drops below the threshold sensitivity of the x-ray telescope is known to $\pm$ 20.5 minutes. The uncertainty is never larger than 95.8 minutes. The vertical extent of the emitting region is calculated from the heliographic coordinates of the center of the underlying CaK region and the solar rotation rate $\omega = 13.39 - 2.7 \sin^2 \lambda$ (degrees/day)[18], where λ is the heliographic latitude. Closely spaced regions of similar heliographic latitude, but different heliographic longitudes, are difficult to distinguish at the limb. Consequently, we have eliminated such cases from consideration for this analysis.

Using data obtained between October 1967 and 1 January 1968, we were able to determine the time of first appearance at the east limb of seven emitting active regions and the time of disappearance at the west limb of eight. Measured vertical extensions ranged from 12,000 km to 193,000 km. The mean height of the top of x-ray emitting active regions was 105,000 km. The results are tabulated in Table III. The accuracy of the proceedure can be estimated from the vertical extents computed for a single region, independently at the east and west limbs. The difference in height observed for region 9073 at the east and west limbs is 12,000 km.

Two major sources of error are present in these estimates. First, the x-ray output of active regions is highly variable. Therefore, the possibility exists that the x-ray emission of the active region could drop below the threshold of detectability because of time variations before the point of geometrical occultation is reached. This would result in an underestimate of the height of the active region. We have attempted to minimize the possibility of this error by considering only the brightest x-ray emitting regions. Second, we have assumed that the top of the x-ray emitting region is located directly above the center of the CaK plage. An uncertainty in the height estimate proportional to the longitudinal extent of the active region is thus introduced.

TABLE III

VERTICAL EXTENT OF ACTIVE REGIONS

McMath Plage No.	Appearance Date (1967)	Time (UT)	Disappearance Date (1967)	Time (UT)	Latitude	Appearance to CMP (days)	CMP to Disappearance (days)	θ (Degrees)	Height (10^3 km)	CaK Area* (CMP)
9034			1 Nov	0839	N12		8.3	20.16	43	3700
9041			6 Nov	1116	N19		9.1	29.24	102	2700
9047			13 Nov	0258	S21		9.6	35.22	157	(6200)
9048			11 Nov	1442	N23		8.6	21.61	53	2500
9066	8 Nov	0319			N20	7.7		10.67	12	2500
9067	8 Nov	0319			N18	9.0		28.19	94	3200
9073	10 Nov	1735			N14	9.2		31.73	123	(7800)
9073			29 Nov	0345	N14		9.3	33.06	135	(7800)
9088	20 Nov	0041			S18	8.3		19.00	40	3100
9091			5 Dec	1543	S28		9.8	35.39	159	1400
9092			9 Dec	2358	S19		9.4	33.18	136	2300
9108	2 Dec	0004			S18	8.5		21.62	48	(3700)
9115			26 Dec	1637	N14		9.7	38.35	193	7500
9118	12 Dec	0633			N21	9.7		36.52	171	9100
9120	14 Dec	0740			S27	9.4		30.64	114	4300

*Millionths of a Solar Hemisphere

In Table III we have listed the CaK area of the active regions as observed near central meridian passage. If we assume that the outline of the base of the x-ray emitting region conforms, in general, to the outlines of the CaK plage (as observed by Vaiana et al.[8], that the topology of all x-ray emitting regions are similar, and that the region does not change in size between the center of the disk and the limb, then the vertical extent of a region should be proportional to the square root of its CaK area. It is evident that this relationship does not hold. It would therefore appear that the shapes of the x-ray emitting portions of active regions differ from region to region.

5.2.3 Size of Flares

One can estimate the size of x-ray flares observed on the disk by comparing the observed x-ray intensity profiles with the expected response of the telescope to sources of various sizes. We have examined the intensity profiles of 42 bright x-ray flares observed between 27 October 1967 and 3 December 1967. For each of these events the diameter of the telescope field stop was one arc-minute. We have compared these intensity profiles with those calculated from the response of the telescope for circular sources of various diameters.[11] Figure 5-2 is a histogram of the relative frequency of occurrence of the measured full widths at half maximum intensity (FWHM). The mean value of the FWHM is 1.51 arc-minutes, which corresponds to a source diameter of 1.24 arc-minutes. The standard deviation of the distribution is 0.30 arc-minutes. We have compared the measured FWHM of the x-ray intensity distributions with the corresponding values of the measured area in Hα for the 24 x-ray events from this sample which were listed as Hα events in the ESSA Solar Geophysical Data Bulletin.[17] There is no apparent

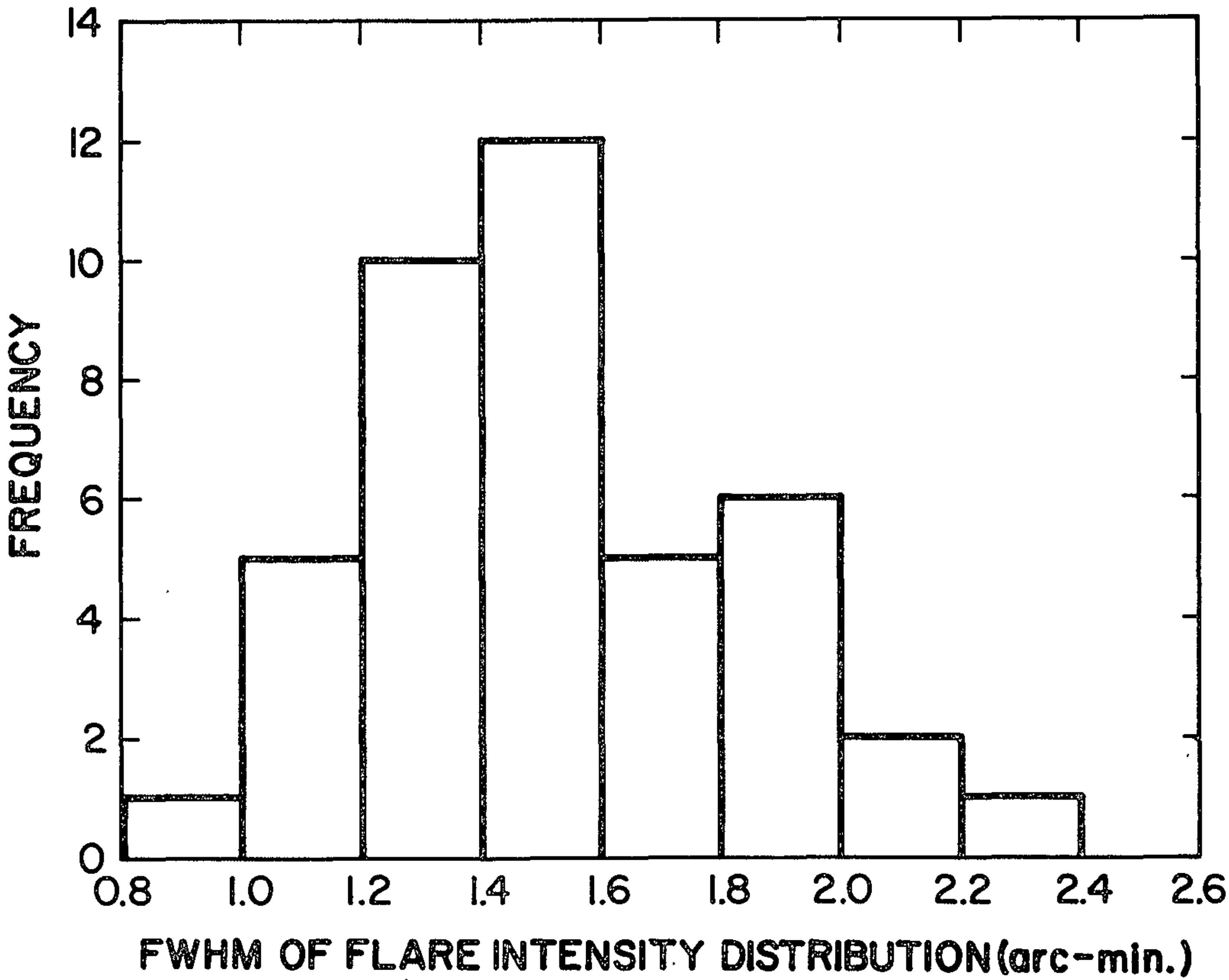


Figure 5-2. Histogram of the relative frequency of occurrence of the measured full widths at half maximum (FWHM).

relationship between the measured area in Hα and the observed width of the x-ray distribution. If the jitter in the OSO-IV pointing control (about 0.25 arc-min) is taken into account, the observed x-ray intensity distributions are consistent with source dimensions of one arc-minute or less.

In a similar manner we have examined the intensity profiles of 10 bright x-ray flares observed at the limb. The mean value of the observed FWHM is 1.64 arc-minutes which corresponds to a source diameter of 1.35 arc-minutes. The standard deviation of the observed distribution of limb flare FWHM is 0.38 arc-minutes. Therefore, the vertical extent of the x-ray flares observed by the OSO-IV telescope would also appear to be on the order of one-arc minute.

From the OSO-IV results, it would appear that the majority of the soft x-ray flux from flares is emitted from regions whose characteristic dimensions are on the order of one arc-minute. We can therefore set an upper limit on the volume of the x-ray emitting region for the observed flares of about 10^{29} cm^3. If we then assume an emission measure, N_e^2V, on the order of 10^{48} cm^{-3} as reported by Culhane and Phillips[19] for the flares observed in the 1 to 3 Å region of the spectrum, the electron density in the x-ray emitting region of the flare must be greater than $10^{9.5}$ cm^{-3}. Gabriel and Jordan[20] have derived electron densities between 10^9 and 10^{11} cm^{-3} for non-flaring active regions. The higher densities could be achieved if the flare regions were filamentary in structure, or if the flare volumes were substantially smaller than the OSO-IV limiting resolution.

5.3 Time Variations in X-ray Emission From Active Regions

5.3.1 The Range of Variation in the X-ray Emission of an Active Region

The magnitude and variety of the changes in the instantaneous x-ray emission observed from an individual active region can be noted by examining a plot of the time history of such a region over a period of several days (Figure 5-3). The most notable feature of this plot is the extreme range of variability in instantaneous x-ray counting rate. The total variation between the highest counting rate shown (15.6 minutes after the x-ray peak of the importance 3b flare of 2130 UT on 16 November 1967) and the lowest rate shown (0513 UT on 10 November) is 160. In order to extrapolate back to the peak of the x-ray flare, we use the fact that the x-ray intensity of the 16 November flare fell exponentially with a time constant of 17.5 minutes. This would indicate a maximum range in the 2.5 to 12 Å x-ray intensity of a factor of 400 in a seven day period. This range is typical of that exhibited by solar active regions during periods of flare activity. For the period 27 October 1967 to 6 January 1968, the maximum range of x-ray flux variation exhibited by an individual active region during a passage across the disk was shown by the region corresponding to McMath-Hulbert Plage No. 9091. This region was below the threshold of detectability, 3.8×10^3 photons/cm^2-sec until 24 November 1967. On December 1967, 0652 UT, we observed a flare with a peak x-ray flux of 6.5×10^6 photons/cm^2-sec. Thus, the range in x-ray flux was at least a factor of 1700.

Even if flares are not considered, the x-ray counting rate for an individual active region varies considerably during a single passage across the disk. The non-flare x-ray counting rate of

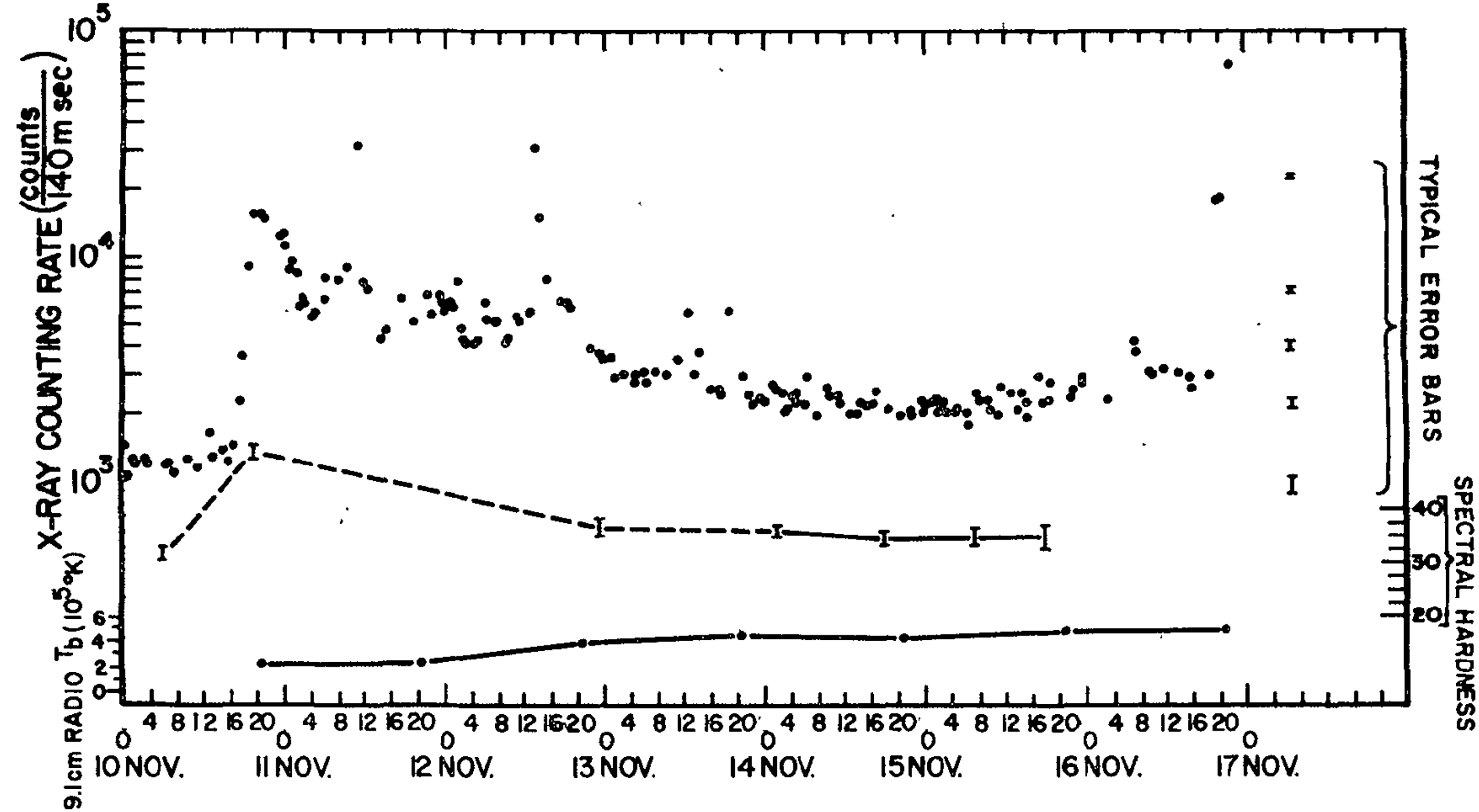


Figure 5-3. Time history of the 2.5 - 12 Å x-ray emission of McMath plage region 9073 for 7 days in November 1967. Also shown are the x-ray spectral hardness (the ratio of emission at 2.5 - 9 Å to emission at 2.5 - 12 Å in percent) and the peak 9.1 cm radio brightness temperature of the region.

region 9073, for example, (shown in Figure 5-3) rose by a factor of twenty in a period of four hours and then slowly fell back to approximately twice its original value over a period of four days. Variations of a factor of ten in x-ray counting rate over a disk passage are typical.

5.3.2 Time Behavior of Active Regions

Intense, impulsive x-ray bursts are immediately obvious on the plot of the time history of the x-ray intensity of an active region (Figure 5-3). Such events appear as a sequence of a few points with substantially higher x-ray flux than the mean level of emission from the active region immediately before or after. Enhancements of a factor of ten in the x-ray photon flux from an active region during an impulsive burst have been observed. Enhancements of a factor of two or three are typical. Because the interval between comparable measurements (20.5 minutes) is of the same order of magnitude as the duration of these impulsive events (see, for example, the data of Teske[21]), the probability of observing the peak of an event is relatively low. Consequently, the flare enhancement in x-ray emission observed by this experiment is, in general, less than the actual enhancement.

In addition to the impulsive x-ray events, the time history of an individual active region reveals more gradual variations in x-ray intensity. The durations of these merge into the longer impulsive x-ray flares. These events may indeed reflect the pre-and post-flare state of the active region. The longer events presumably contribute to the slowly varying component of the solar x-ray emission.

In general, the time profiles determined from the OSO-IV data are affected by the presence of unresolved rapid fluctuations in x-ray brightness. Figure 5-4 illustrates this point. The time history of the x-ray emission in the three OSO-IV wavebands is shown for two active regions. Also shown are higher time resolution, 2 to 12 Å total solar x-ray flux measurements for this period[22]. One effect of the low time resolution of the OSO-IV instrument is to increase the apparent duration of the impulsive x-ray flares. However, the x-ray images allow the identification with only small ambiguity of the active regions responsible for the impulsive bursts. Moreover, by comparison with high time resolution data, it is easy to distinguish those portions of the OSO-IV data which are affected by the impulsive x-ray bursts. By means of comparisons between the OSO-IV data and higher time resolution total solar x-ray flux measurements, we have been able to distinguish periods in which the time history of a particular active region is unaffected by unresolvable fluctations.

For convenience in analysis, we have chosen to divide the x-ray event arbitrarily into three classes on the basis of their durations. Events of duration less than 8 hours are termed "flares". Events of duration greater than 24 hours are called "slow variations". Events with intermediate duration are termed "long enduring brightenings".

The establishment of three separate classes of events is quite arbitrary. It is difficult to distinguish between the shorter duration members of the intermediate class and impulsive events. It is sometimes equally difficult to distinguish between long enduring brightenings and slow variations. In general, however, gradual brightenings appear to be superposed on slow variations and flares on gradual brightenings (as in Figure 5-3).

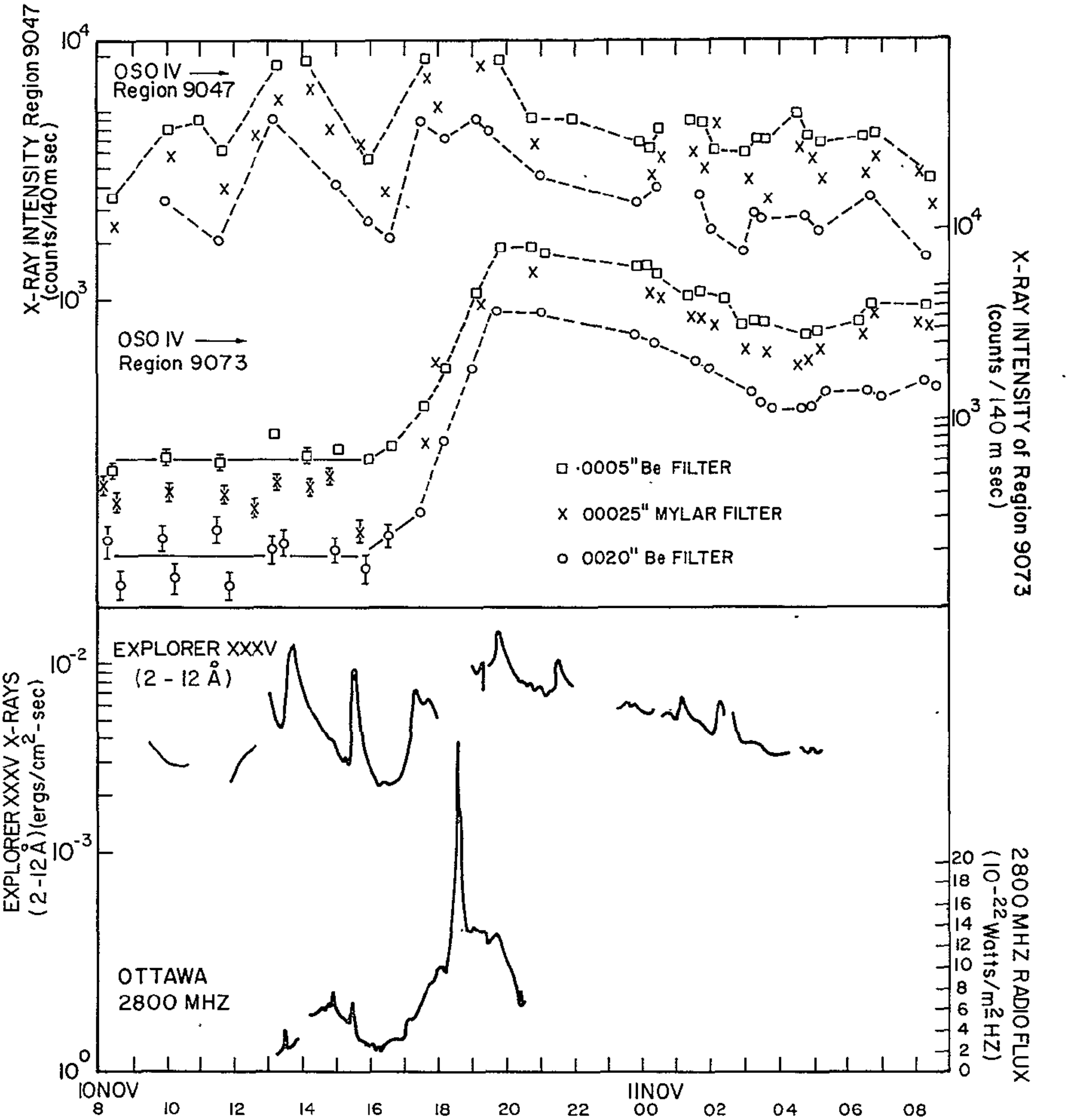


Figure 5-4. Solar activity from 10 November, 08^h UT, to 11 November 1967, 09^h UT. The top half of the graph shows the x-ray activity from two active regions as observed on OSO-IV. The bottom half shows tracings of data from Explorer XXXV (2 - 12 Å) and 2800 MHz radio flux.

The relationship between long enduring brightenings of the active region and the occurrence of large x-ray flares tends to justify our classification. We have selected the 12 impulsive x-ray events with peak-observed flux in the 2.5 to 12 Å waveband (0.0005 inch Beryllium filter) greater than or equal to 5×10^6 photons/cm^2-sec which occurred during the period 27 October to 3 December 1967. Three of these events occurred at times when the non-flare level of x-ray emission from the active region was below the threshold of sensitivity of our detector. The time behavior of the active region before and after the 9 remaining events was examined. In all 9 cases, the large flare occurred during the course of an x-ray brightening of duration between 6 and 18 hours.

We have also examined 16 easily identifiable long enduring x-ray brightenings. Of these, only 9 produced major x-ray flares with peak flux greater than 5×10^6 photons/cm^2-sec. In fact, no impulsive x-ray events were observed at all in the case of 3 of these gradual x-ray brightenings. An examination of the fast time resolution records of Explorer XXXV[22] in the 2 to 12 Å band and OSO-III in the 1 to 1.6 Å band[23] confirm these results. Therefore, we can conclude that although the existence of a gradual x-ray brightening seems to be required for the occurrence of large impulsive x-ray flares, the existence of a gradual x-ray brightening does not necessarily imply that such a flare or indeed any x-ray flares will occur.

In Table IV, we list some of the observed characteristics of the three event classes. The quantities listed are the extremes of the range of measurements made on 49 flares, 16 gradual events, and 7 slow variations. The ranges of duration of the three classes are defined. The peak fluxes are calculated from the

TABLE IV

TYPICAL CHARACTERISTICS OF THREE EVENT CLASSES: MEASURED QUANTITIES

	Flares	Long Enduring Enhancements	Slow Variations
Duration	< 5 min. - >1 hr.	8 - 24 hrs.	2 - 5 days
Peak Flux	10^{-3} - 10^{-2} ergs/cm^2-sec.	10^{-3}-5 x 10^{-3} ergs/cm^2-sec.	10^{-4}-10^{-3} ergs/cm^2-sec.
Total Emission (2.5 - 12 Å)	1 - 10 ergs/cm^2	10-10^2 ergs/cm^2	10-10^2 ergs/cm^2
Rise Time	<20 min.	1 - 5 hrs.	1/2 - 4 days
Decay Time	<20 min. -1 hr.	2 - 6 hrs.	1/2 - 4 days
Spectral Hardness Index*	>50	40	35

*Spectral Hardness Index is the relative x-ray intensity observed in two wavebands. It is a measure of the effective temperature of the emitting regions.

peak x-ray counting rate extrapolated from the observed time behavior of the event. The conversion from counting rate to energy units is performed by assuming an exponential spectral shape characterized by the measured spectral hardness index (defined below). The total output in the detector passband observed at 1 a.u. is obtained by numerical integration of the event time profile. The range of total output values is listed by order of magnitude. The rise and decay times are the time constants of exponential fits to the event counting rate profiles observed through the 2.65 $\mu gm/cm^2$ Beryllium filter. The peak spectral hardness index is the ratio of the counting rate measured through the 9.4 $\mu gm/cm^2$ Beryllium filter to the rate measured through the 2.65 $\mu gm/cm^2$ Beryllium filter (in percent) at the peak of the event. The spectral hardness index increases as the x-ray spectrum becomes enhanced in shorter wavelength photons.

Examination of Table IV shows that the total energy emitted at in the detector passband for each of the three event classes is roughly comparable. The lower peak fluxes of the longer time scale events are compensated by their longer durations. The peak spectral hardnesses for the event classes decrease as the duration increases, implying higher temperatures for the more impulsive events, but there is substantial overlap.

Since the total output in the detector passband from each type of event is comparable, the majority of the energy emitted by an active region will be emitted during the course of the most numerous events. Thus it would appear that the greatest portion of the total observed output in the detector passband would come from flares. In fact, this proves to be the case. We have integrated over time to find the total energy emitted in the detector passband by the active region corresponding to McMath plage 9073. Over the eighteen days that this region was observed, it emitted a total of $1.7 \pm 0.5 \times 10^{30}$ ergs in the 2.5 - 12 Å band. The importance 3b flare of 16 November 1967 alone emitted $4.2 \pm 0.8 \times 10^{29}$ ergs of this energy.

5.3.3 Spectral Behavior of Active Regions

We have attempted to fit the rising and falling portions of x-ray events to exponential curves. This is done independently for the three different x-ray filters. In general, the exponential rise and decay times are found to be shorter for the same event observed through the thicker filters than through the thinnest. For example, in the case of the event of 1630 UT, 10 November 1967 (Figure 5-4), the rise time as observed through the 2.65 $\mu gm/cm^2$ Beryllium filter (2.5 to 12 Å) is 73 ± 5 minutes. The rise time measured for the 9.4 $\mu gm/cm^2$ Beryllium filter data (2.5 to 9 Å) is 51 ± 7 minutes. Similarly, the decay times are 325 ± 25 minutes for the thinner filter and 260 ± 20 minutes for the thicker filter. Thus, the x-ray spectrum becomes enhanced in higher energy photons as the event rises toward maximum intensity. During the decay phase, the spectrum softens. This behavior has been noted for 9 cases in which there is a statistically significant difference in the characteristic times for the two Beryllium filters. In 13 other cases, there was no significant difference in the characteristic times. No events have been measured in which the spectrum softens towards the peak of the event.

In Figure 5-5 we plot the relationship between the counting rates measured through the 0.0005 inch Beryllium filter and the spectral hardness index for the bright active region shown in Figure 5-3. The relationship between spectral hardness and

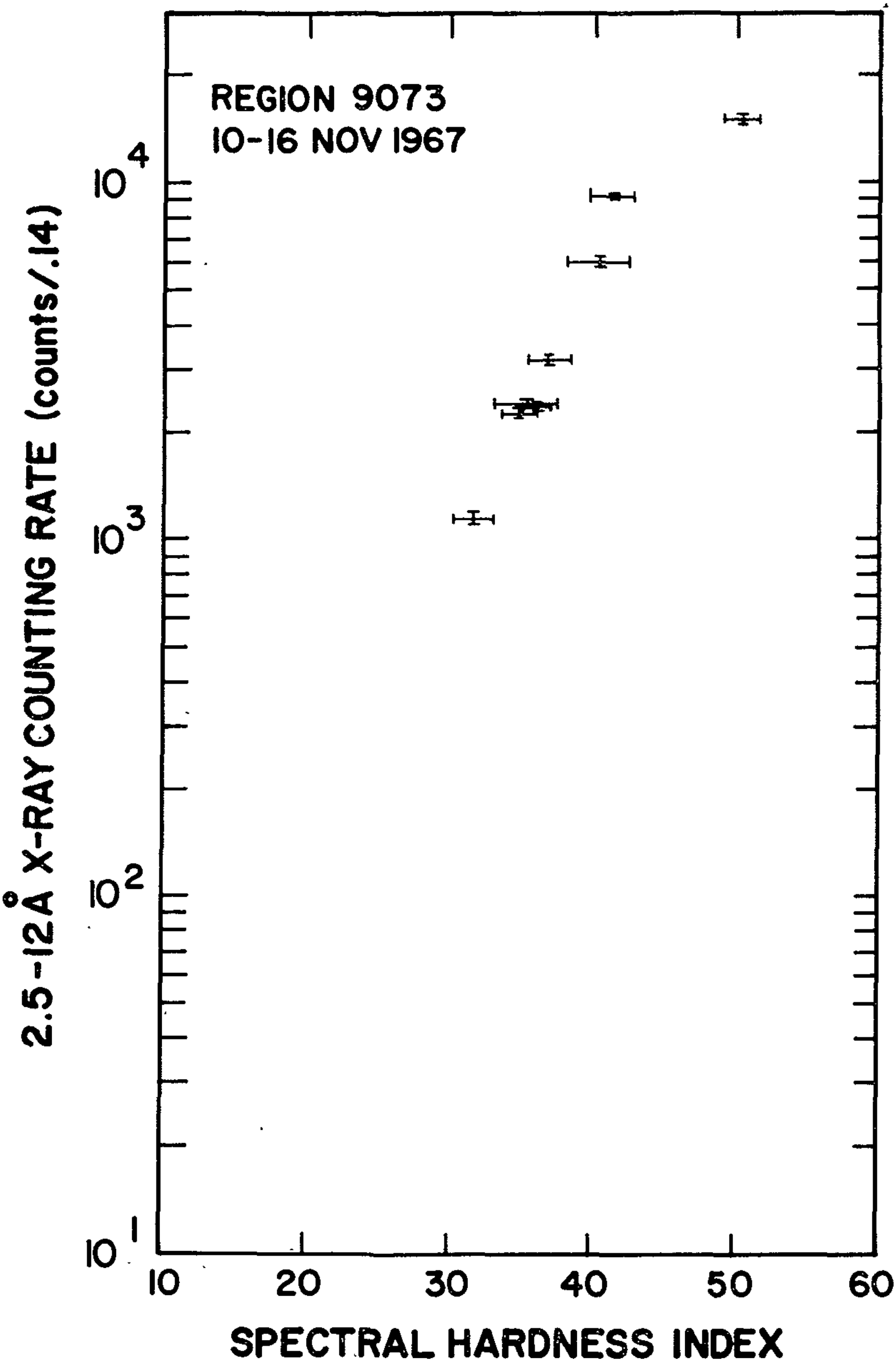


Figure 5-5. Relationship between the 2.5 - 12 Å x-ray emission and the spectral hardness index for McMath region 9073.

x-ray counting rate is monotonic within the experimental errors. If we assume that 2.5 – 12 Å x-rays are produced by thermal mechanisms, the spectral hardness index will be related to the temperature of the emitting plasma. The exact form of this relationship depends on the shape of the x-ray spectrum as a function of temperature including the effect of emission lines. The x-ray counting rate, on the other hand, is a function not only of the temperature, but also of the emission measure. Thus the monotonic relationship between the counting rate and the spectral hardness index shown in Figure 5-5, implies that for the six day period plotted in Figure 5-3, either the emission measure of this active region did not change significantly, or changes in emission measure are proportional to temperature. If an exponential shape is assumed for the x-ray spectrum, a limit of a factor of 3 can be put on possible changes in the emission measure of the region.

Observations of impulsive x-ray flares at shorter wavelengths by Culhane and Phillips[19] and by Hudson et al.[23] have shown that the emission measure remains constant during the decaying portion of such events. Here, over a much longer time scale we observe a relatively constant emission measure in a single active region. However, there are significant differences in emission measure from region to region. For example, during the period on 10 November 1967, shown in Figure 5-4, the x-ray counting rates observed from region 9047 were a factor of five higher than the rates observed from region 9073 at the same value of the spectral hardness index.

5.4 Relationship Between X-rays and Other Solar Emissions

5.4.1 X-ray and Hα Flares

In general, individual x-ray impulsive events are associated with individual $H\alpha$ flares. Teske and Thomas[24] have shown that, with only one possible exception, all $H\alpha$ flares of importance one or greater are accompanied by an impulsive soft x-ray event. Most, if not all, subflares are also accompanied by detectable x-ray emission.

The reverse correlation is not quite as obvious. Many x-ray events occur in active regions which are at or beyond the limb in $H\alpha$. Thus the $H\alpha$ event, if any, accompanying a particular x-ray event may be unobservable. We have selected a set of x-ray events for which there was a high probability that any accompanying $H\alpha$ event could be observed. The center of intensity of the x-ray event was required to be within 75° of the central meridian. The x-ray intensity was required to be at least 2.5×10^{5} photons/cm^{2}-sec.

Between 27 October and 3 December 1967, 35 impulsive x-ray events were observed which satisfied these conditions. A search was then made of the solar flare listings of the ESSA Solar Geophysical Data Bulletin. An x-ray event was considered to have an $H\alpha$ counterpart if an $H\alpha$ flare or subflare was found in the active region producing the x-ray event with the time of $H\alpha$ maximum occurring within 10 minutes of the x-ray maximum.

$H\alpha$ counterparts were identified for 32 of these 35 x-ray events. $H\alpha$ events varied in importance from f to 3b. In Figure 5-6 we have plotted the peak observed x-ray intensity as a function of $H\alpha$ importance classification for those events observed with the 2.5 to 12 Å filter. Although there may be a tendency for large x-ray events to be associated with $H\alpha$ flares of greater importance, a large range of $H\alpha$ importance classifications can be covered at moderate x-ray intensities.

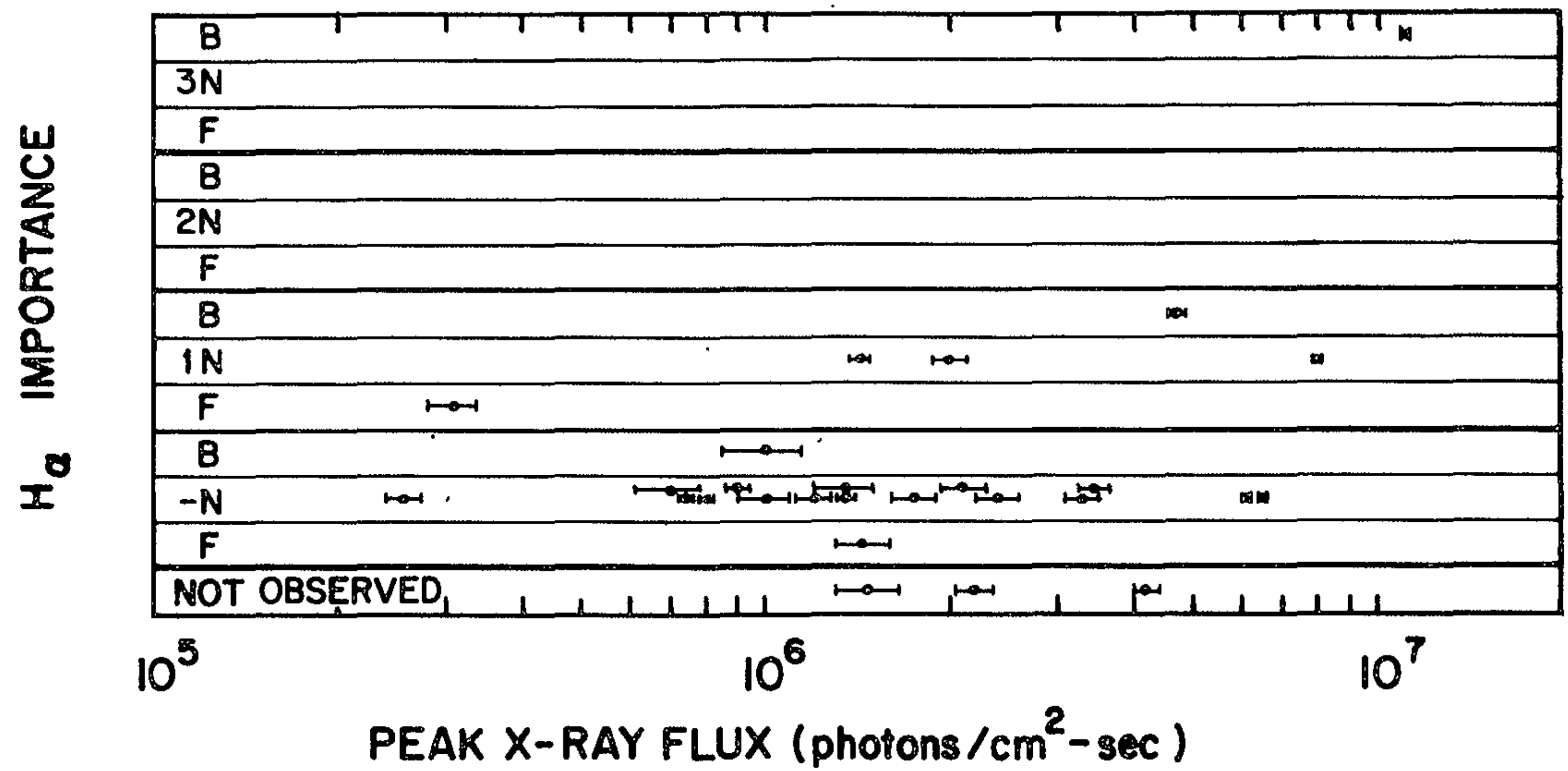


Figure 5-6. Hα importance clissification of solar flares as a function of peak x-ray photon flux.

It would appear that virtually all x-ray events with intensity at 1 a.u. in the detector passband greater than 2.5×10^5 photons/ cm^2-sec are accompanied by $H\alpha$ flares. However, these results show that the magnitudes of $H\alpha$ and x-ray emission associated with a particular event are not well correlated.

5.4.2 X-ray Active Regions and the Slowly Varying Component of the Radio Flux

The general correlation between solar soft x-ray emission and microwave emission is well known.[25] We have already mentioned the correspondence in location between the x-ray emitting regions and the sources of the 9.1 cm radio flux. Several observers[2,16] have noticed the general correlation between the peak radio brightness temperature, T_b, of a solar active region and its x-ray flux.

We have compared the 9.1 cm peak brightness temperature of active regions measured by the Stanford Radio Astronomy Institute[17] with the value of the x-ray photon flux measured by the OSO-IV telescope at the same time. Figure 5-7 shows this comparison. Measurements made during impulsive x-ray flares have been omitted. There is a strong tendency for high x-ray flux to be accompanied by high T_b; however, there is a significant scatter in this relationship. One could conjecture that this scatter is due to the variations between active regions. On the other hand, it is easily shown that even for a single active region, the relationship between 2.5 to 12 Å photon flux and 9.1 cm T_b is not monotonic. Figure 5-8 shows the trajectories on the N_x, T_b plot of individual regions of high activity. In Figure 5-8 A the x-ray flux actually decreases as the radio brightness temperature increases. The trajectory of another active region (McMath 9091) is shown in Figure 5-8 B. Here,

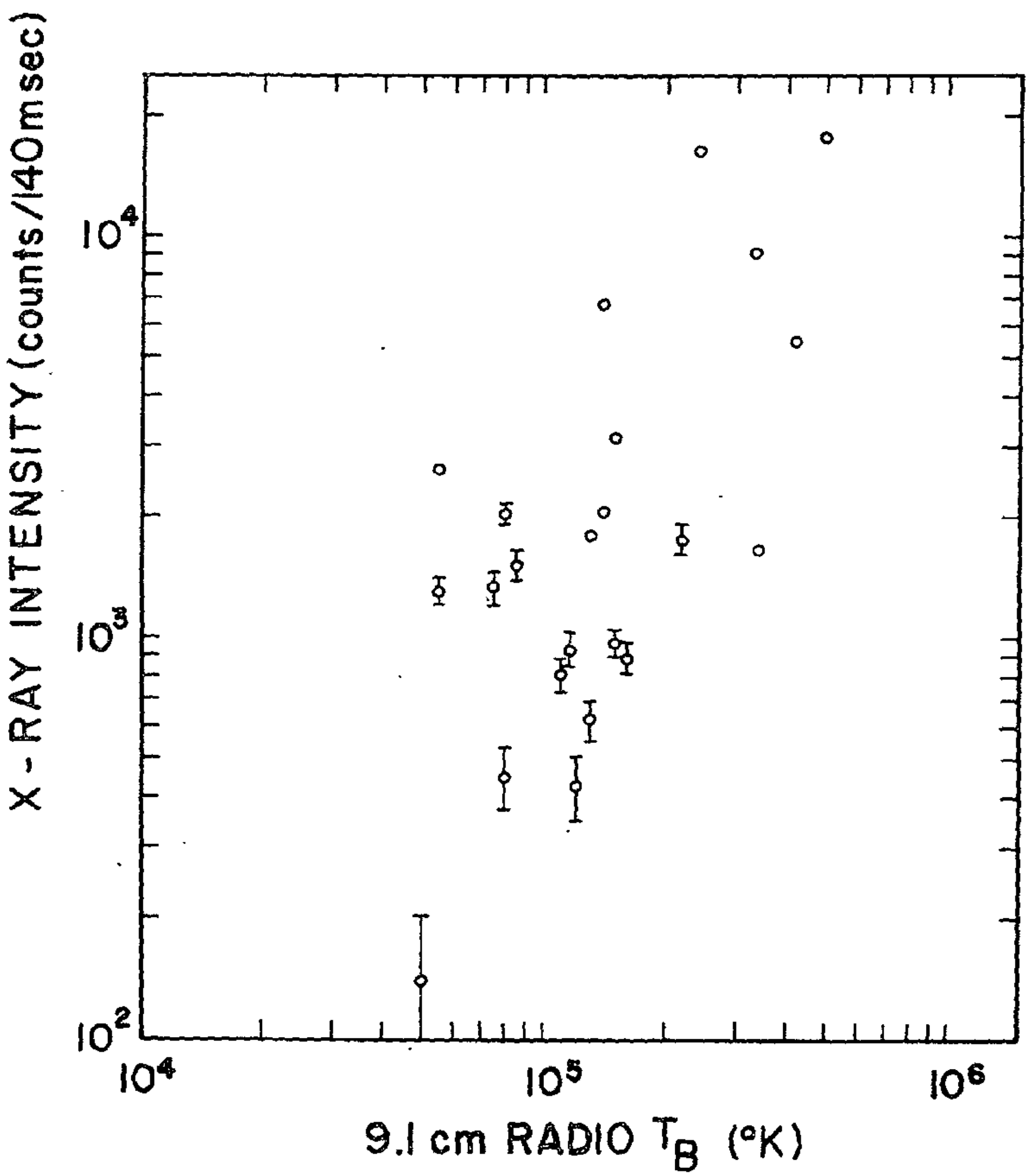


Figure 5-7. Comparison of x-ray photon flux and 9.1 cm peak brightness temperature for individual active regions.

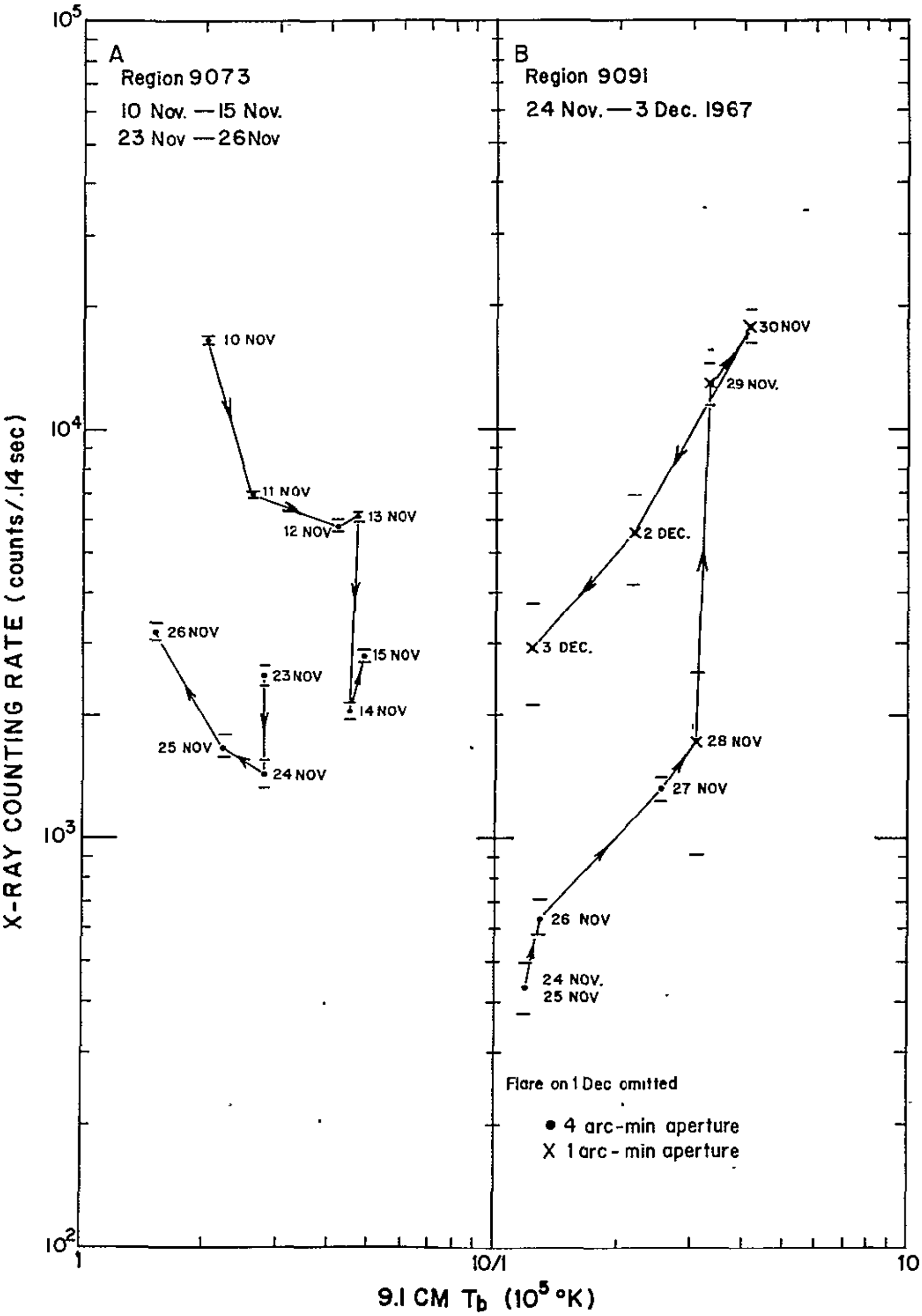


Figure 5-8. Time behavior of the x-ray photon flux from individual active regions as a function of 9.1 cm radio brightness temperature. The trajectories of two active regions are shown.

in general, the x-ray counting rate is proportional to the radio brightness temperature, however, a large increase in x-ray emission is accompanied by only a small change in radio brightness temperature.

Although the behavior of these two regions is different, both types of behavior may be understood, at least qualitatively, in terms of a model in which both x-rays and microwaves are emitted thermally from the same plasma.

During the period between 10 November 1967 and 15 November 1967 spectral hardness data was obtained for region 9073. This data implies in the context of a thermal model that the emission integral of the region remained constant while the electron temperature decreased. If the emitting region is considered optically thin to 9.1 cm radiation and if this radiation is emitted by the thermal bremsstrahlung process, the radio brightness temperature should increase as the x-ray intensity decreases, $T_b \sim T^{-1/2}$.[25] On the other hand, the generally linear relationship between T_b and the x-ray intensity of region 9091 might indicate that the temperature of this region remained constant while the emission measure increased. The jump in x-ray intensity at constant radio brightness temperature might indicate an increase in temperature, and the ensuing decrease in both T_b and x-ray intensity might indicate a drop in emission measure at constant temperature. Unfortunately, spectral hardness information was not obtained during this period and so the temperature behavior of the region is unknown.

The behavior observed for region 9073 is inconsistent with a model in which the region is optically thick to 10 cm radiation.

If the region were optically thick, the observed decrease in both the spectral hardness and x-ray flux would have been accompanied by a decrease rather than an increase in radio brightness temperature.

5.4.3 X-ray Events and Microwave Bursts

Several observers[24,26,27,28] have studied the relationship between soft x-ray flux increases and microwave radio bursts. Detailed correlation for any but the largest events has been hindered by the lack of spatial resolution and also the concomitant low signal-to-noise ratios. This problem is alleviated by imaging x-ray detectors, such as that of OSO-IV, in that the region responsible for the x-ray emission can be identified and analyzed independent of the x-ray flux from other active regions.

As a preliminary step, we have established the statistical relationship between reported 10 cm radio bursts and the soft x-ray events observed by the OSO-IV telescope. During the period 27 October to 3 December 1967, 62 distinct outstanding events of all classes at 2700 and 2800 MHz were reported by Covington, Gagnon and Moore.[29] For this analysis, we have considered complex events as single events. Fifteen events occurred while the spacecraft was either within the earth's shadow or passing through regions of high trapped particle flux. X-ray brightenings of at least two standard deviations in the flux from an individual active region were observed in conjunction with 43 of the remaining 47 outstanding events at 10 cm. Three of the four radio bursts that were not observed to be x-ray events were of duration less than the 307 seconds necessary to complete a solar scan. None of the radio bursts which were unobserved in x-rays exceeded 4×10^{-22} watts-m^{-2}

$-Hz^{-1}$ in peak flux at 2800 MHz. Thus, of the 39 centimeter wave radio bursts of duration longer than five minutes, 38 produced noticeable x-ray brightenings. Similarly, 37 of the 38 centimeter radio bursts with peak flux greater than 3×10^{-22} watts-m^{-2}-Hz^{-1} produced noticeable x-ray brightenings regardless of duration. We therefore consider it to be reasonably certain that any radio event of longer duration than 5 minutes and greater peak flux than 4×10^{-22} watts-m^{-2}-Hz^{-1}, has an observable x-ray counterpart.

Kawabata[30] has pointed out the statistical correlation between long enduring microwave radio bursts (both gradual rise and fall bursts and post burst increases) and soft x-ray flux enhancements. We have examined the relationship between a specific long enduring microwave burst at 2800 MHz and the corresponding x-ray event. Analysis of this type is necessarily restricted to those events whose durations are long compared to the 20.5 minute time resolution of the OSO-IV instrument.

During the period 1650 UT to 2030 UT on 10 November 1967 (shown in Figure 5-4), Covington, Gagnon and Moore[29] distinguish two separate radio events at 2800 MHz. One is a complex event which we associate with the impulsive x-ray bursts observed by the solar x-ray flux monitors. Most of these impulsive bursts can be attributed to region 9047. The second microwave event is a gradual rise and fall radio burst (simple 3A) which we associate with the x-ray brightening of region 9073.

In Figure 5-9 we show the time histories of the 2800 MHz simple 3A burst[31] and the x-ray brightening of region 9073. If the association of the radio event with the x-ray event is correct, we see that the x-ray brightening begins slightly earlier than

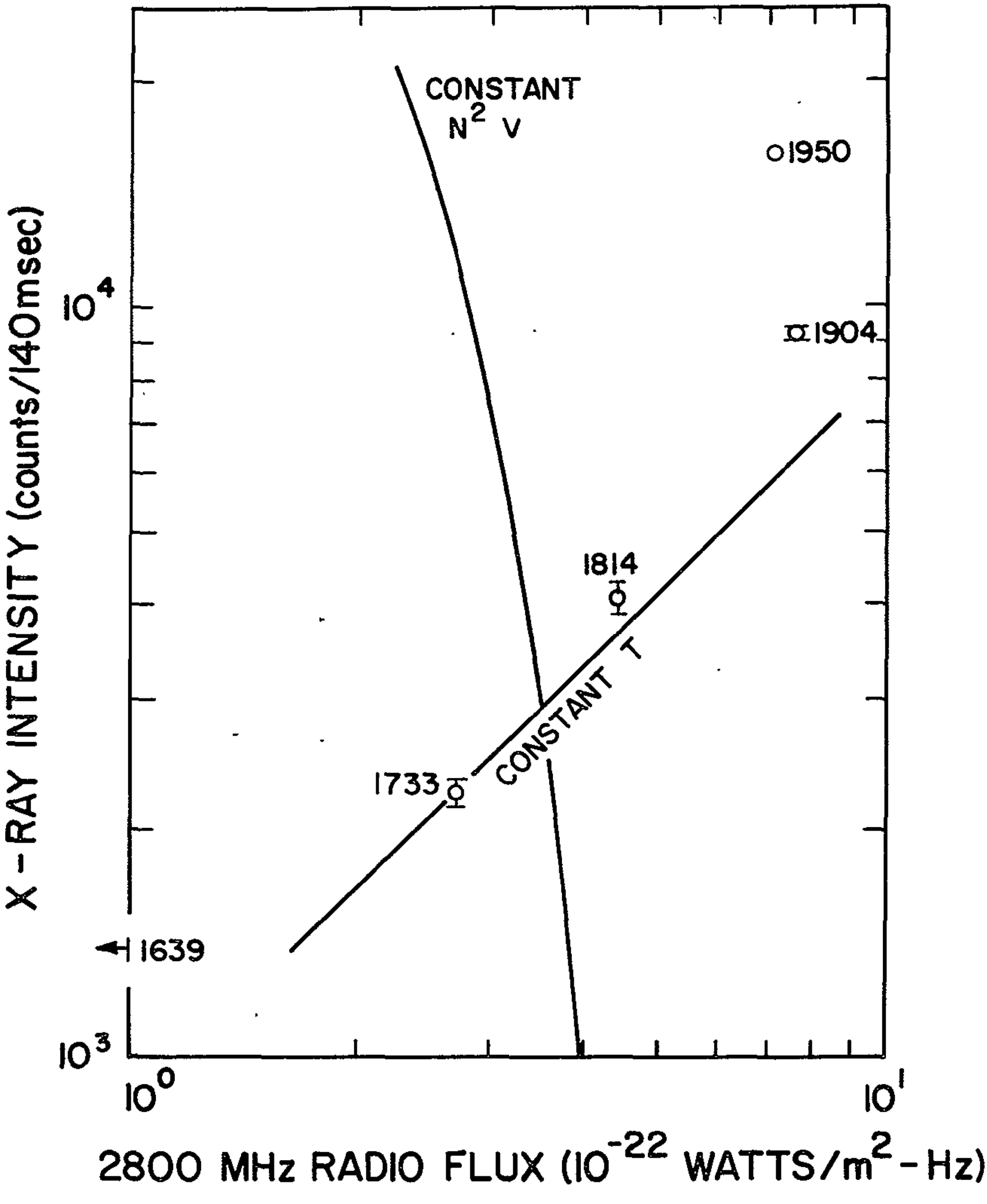


Figure 5-9. Trajectory of the x-ray photon flux and 2800 MHz radio flux of and active region during the rise phase of a long enduring burst. The time (UT) at which a measurement was taken is listed next to the data point. Loci of constant temperature and constant emission measure are shown for a model in which both the x-ray and microwave optical depths are small.

the radio burst and continues for much longer. The x-ray intensity rises to two standard deviations above the previous mean level at 1640 UT. The radio burst is listed as starting at 1650 UT.[29] The duration of the radio burst is given as 220 minutes. The duration of the x-ray event is at least 650 minutes. The time of the peak of the x-ray event is somewhat uncertain, but it is clear that the peak of the radio burst occurs 20 to 40 minutes before the peak of the x-ray event. The presence of this substantial time delay would appear to argue against models in which the long enduring radio burst and long enduring x-ray burst are produced by the same mass of plasma by a thermal process.

6.0 CONCLUSIONS

The OSO-IV pointed x-ray telescope experiment continues to function satisfactorily. Since the failure of the second tape recorder on OSO-IV on 12 May 1968, only data transmitted during real-time passes over the receiving stations has been available. Recently the amount of quick-look data received from GSFC has been greatly reduced, because of the telemetry overload on the Stadan network. At the time of tape recorder failure, the detector efficiency of the OSO-IV telescope was about 30% of its value on 27 October 1967. Since then it has stabilized at somewhat less than 20% of this value.

The instrument has been operated almost entirely in its most sensitive mode (0. 0005 inch Beryllium filter; 4 arc-minute aperture) since tape recorder failure. Occasionally it is commanded into the calibration mode for reference. Despite the decrease in sensitivity, the instrument can still detect all major flares that occur on the sun during our real-time passes.

As mentioned earlier in this report, information obtained with the OSO-IV x-ray telescope has been exchanged with other experimenters, including those from the University of Iowa, University College of London, Algonquin and Dominion Astrophysical Radio Observatories, the Stanford Radio Astronomy Institute, the University of Hawaii, the University of Maryland and the University of California at San Diego. Results of the data analysis have been presented to the scientific community at various meetings. Abstracts or reports are available for some of these meetings[3, 4, 5, 6]. Others include two papers presented at the Midwest Cosmic Ray Conference in Iowa City, Iowa, in March, 1968: Paolini, F. R.; Vaiana, G. S.; Giacconi, R.;

Reidy, W. P. and Zehnpfennig, T., "Spectroheliograms of X-ray Flares from OSO-IV," and Vaiana, G. S.; Paolini, F. R.; Giacconi, R.; Reidy, W. P. and Zehnpfennig, T., "X-ray Plage Studies from OSO-IV." A paper by Vaiana, G. and Krieger, A. entitled "Results from the OSO-IV Solar X-ray Telescope (3 - 13 Å)" was given at the Fiftieth Annual Meeting of the AGU from 21 - 25 April 1969 at Washington, D. C. A presentation entitled "Results from the OSO-IV Soft X-ray Telescope Experiment" by Giacconi, R.; Vaiana, G. and Krieger, A. was made at the Orbiting Solar Observatory Workshop at Boulder, Colorado, from 4 - 15 August 1969. A paper is in preparation reviewing the results of the OSO-IV telescope experiment as presented in this report.

7.0 OSO-IV: STELLAR X-RAY WHEEL EXPERIMENT

The Wheel Experiment, which was designed to measure cosmic x-rays, malfunctioned early in the flight. Also during the short time that it operated, it was apparent that the sensitivity of the primary instrument, the photoelectric detector (PED) was well below that determined during the final calibration, possibly as a result of degradation of the electron-multiplier between the time of the final calibration and the launch.

The malfunction in the form of high counting rates was observed in the PED beginning sometime between 17 and 18 November 1967. This was apparently caused by a malfunction of our instrument, but it was never possible to isolate the nature or the origin of the malfunction.

There was no indication that the high counting rate was caused by factors associated with the spacecraft, and there was no indication that the spacecraft was adversely affected by the malfunction. The malfunction was characterized as follows:

1. There was a high counting rate (100 counts per second) induced in the PED. The onset of this high rate was not necessarily coincident with the turn-on of the instrument at night. The time delay varied between a few seconds to half an orbit. Following its onset, the high counting rate persisted with some fluctuation until turn-off.

2. The NaI detector in its high gain state was also being affected, although the increase was not as large as it was in the PED.

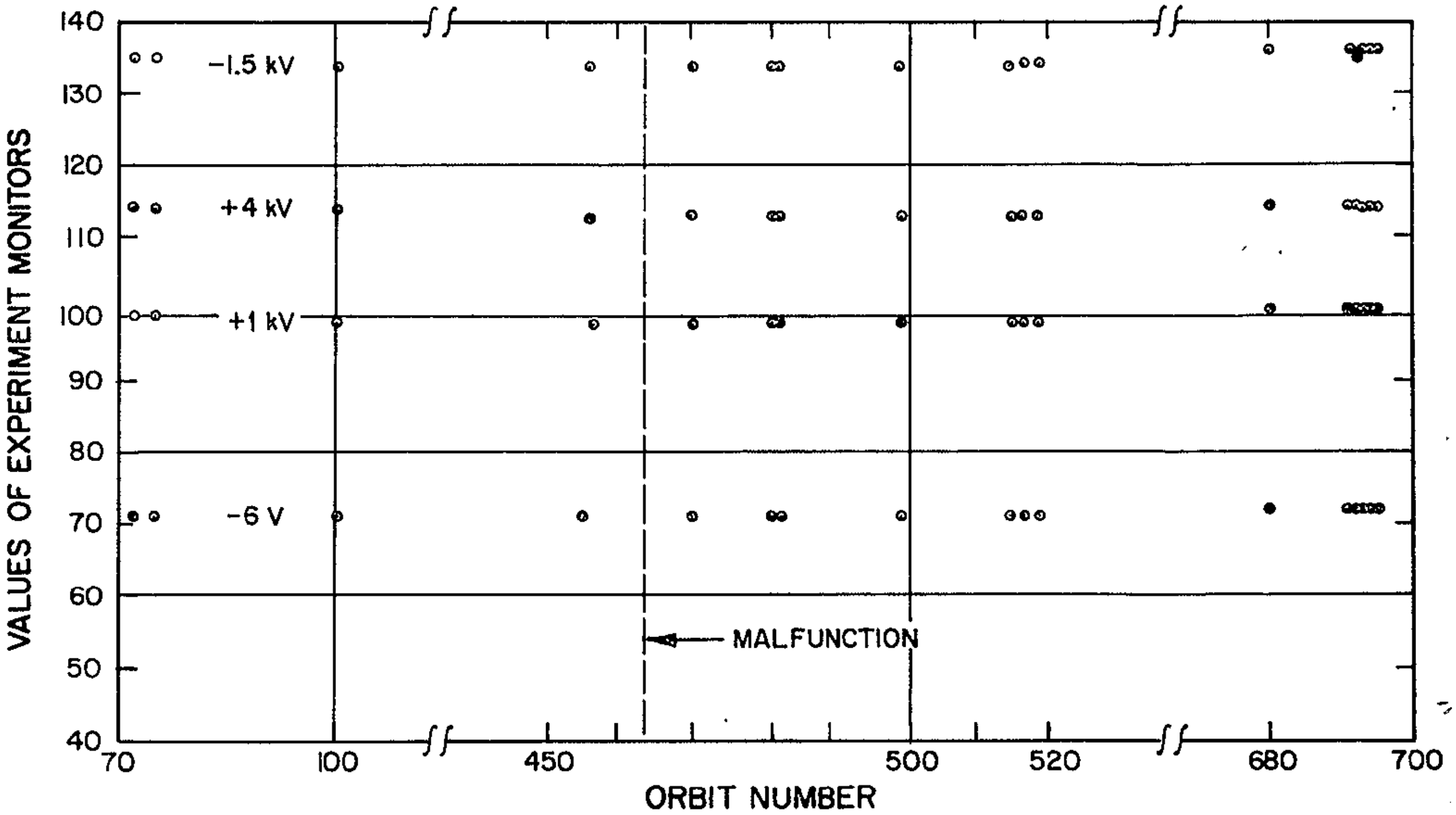
3. The remaining detectors, the anthracene and the anti-coincidence, were not affected.

The various housekeeping functions incorporated into the instrument did not show any significant variation since launch. A plot of the values of the monitors for a number of orbits is shown in Figure 7-1. The small changes that occurred were consistent with drifts in the analogue circuitry and in the A/D converter. Thus, the malfunction was not a result of a power supply failure, nor was it adversely affecting the power supply. Figure 7-2 is a plot of the onset time of the high counting rate in units of ASC frames following turn-on through Orbit 700. There appears to be significant differences in the onset time, particularly between Orbits 530 and 620. However, it was not yet clear what the significance was.

Plotted in Figure 7-3, 7-4, 7-5 and 7-6 are the counting rates around the orbit for the several detectors for a series of four consecutive orbits. Figure 7-3 shows the PED count rates. For Orbits 619 and 620 the count rate was low and apparently normal for about half the night. Figure 7-4 shows the count rate in the anthracene detector. A large peak is observed at around 0° longitude indicating passage through the South Atlantic Anomaly. Elsewhere the anthracene detector is apparently counting normally; in particular, no abrupt change is noted in coincidence with the onset of the high count rate in the PED. Figure 7-5 shows the count rate in the plastic anticoincidence detector. Again the South Atlantic Anomaly is apparent at 0° longitude. In addition, variations around the orbit are noted, which can be correlated with changes in the cosmic ray fluxes associated with the changing magnetic latitude. Again, no increase is observed coincident with the onset of the high rate in the PED. Figure 7-6 shows the count rate in the NaI detector. As noted in our earlier report,[15] the NaI detector exhibits a more complex counting rate profile around the orbit than any of the other detectors, which simply reflects the fact that the device is sensitive to a greater variety of radiation than the others. The South Atlantic Anomaly is apparently a variation dependent on magnetic latitude. There is also an indication of an increase in count rate coincident with the increase that occurs in the PED, but of a much smaller magnitude.

The conclusions from these data are that the malfunction was causing extraneous counts to be thrown into the PED channel and to a lesser extent into the high gain state of the NaI detector, but that these detectors were still functioning, both before and after the onset of the high rate. As noted, the remaining detectors and the lower gain states of the NaI detector were apparently not being affected. The implication of this malfunction, as far as the experiment is concerned, can be summarized as follows. Little or no useful data could be obtained from the PED, which is the primary x-ray detector during the high count rate phase. The signal-to-noise ratio in the high gain state of the NaI detector is being adversely affected by perhaps a factor of 2. Under these conditions, a significant number of the primary scientific objectives of the experiment could not be met.

We attempted to understand the origin of the malfunction without success. The basis for considering it to be a malfunction and not simply an increase in count rate due to radiation is primarily the failure to connect the observed rates with anything physically real. There was no apparent variation of the count rate in the PED with filter wheel position, nor are there any systematic variations with time or around the orbit as might be expected to occur with charged particles; neither was there an up-down asymmetry of the radiation. In addition, the sudden onset of the high rate is difficult to understand as a real increase due to radiation. The appearance is that of some component that was being overstressed either electrically or perhaps thermally and suddenly becoming very noisy. An example of this might be voltage breakdown of a capacitor. No malfunction of this kind has been observed during the entire OSO Wheel Instrument test and qualification program. The only malfunctions that occurred have been catastrophic failures induced by high voltage discharge during thermal vacuum tests. On at least two occasions, we did experience high count rates induced by RF interference. This occurred only when the arms were in a down position and affected only the high gain state of the NaI detector. Thus, we did not feel that this malfunction was related to an RF problem.

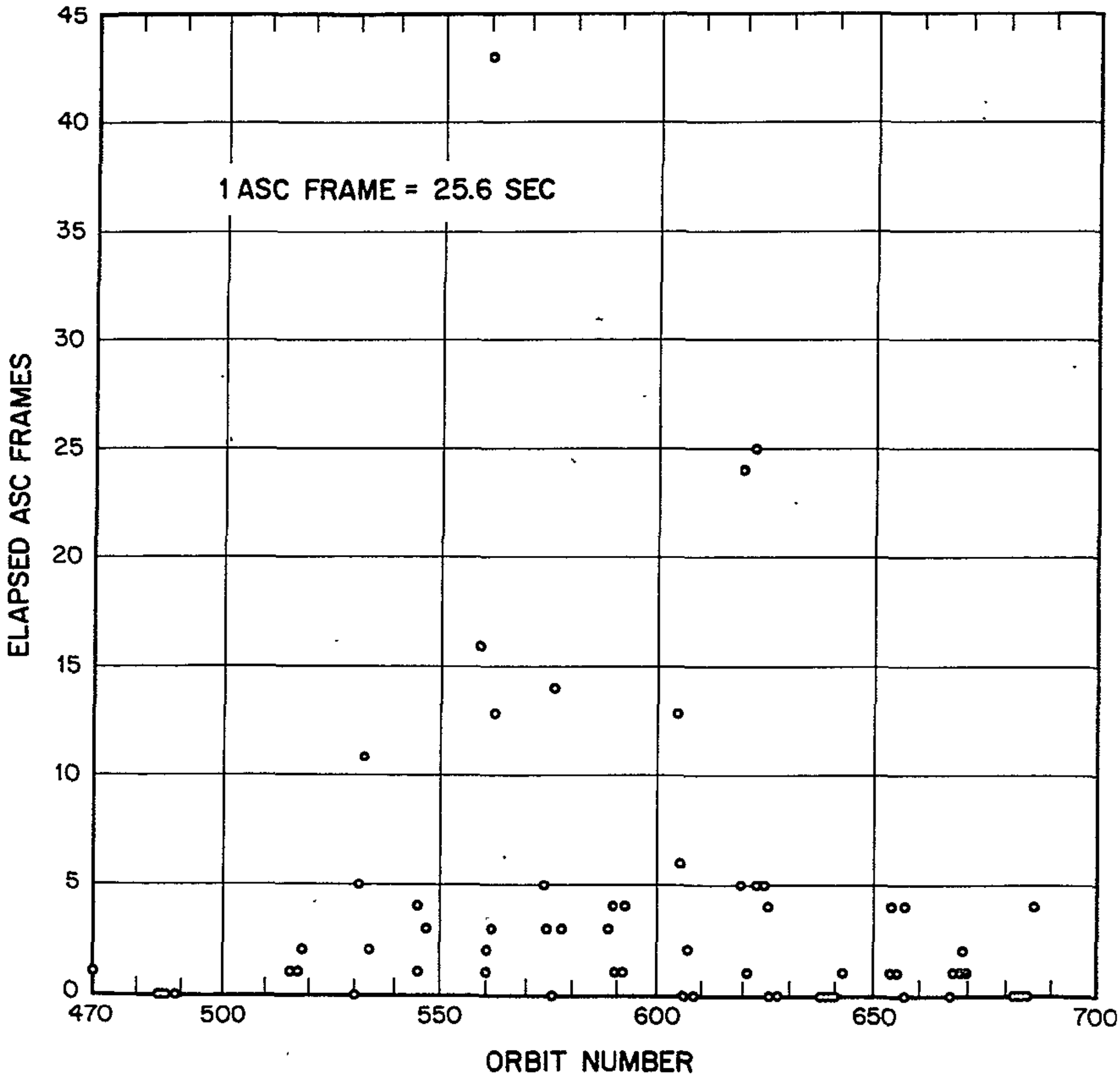


MONITOR READINGS AS&E WHEEL EXPERIMENT

Figure 7-1

1816

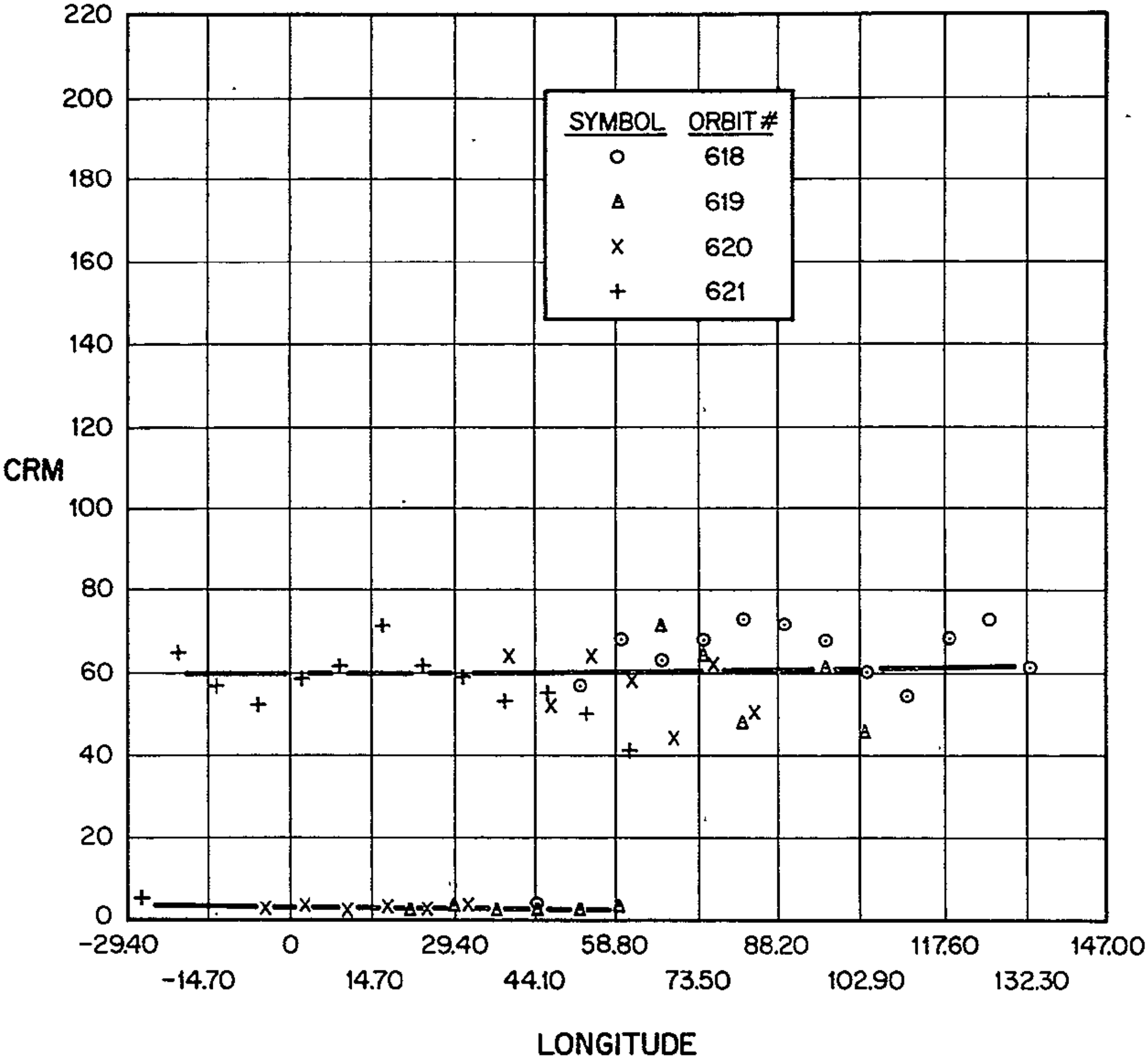
NUMBER OF ELAPSED ASC FRAMES BETWEEN TURN ON AND ONSET OF MALFUNCTION



1816

Figure 7-2

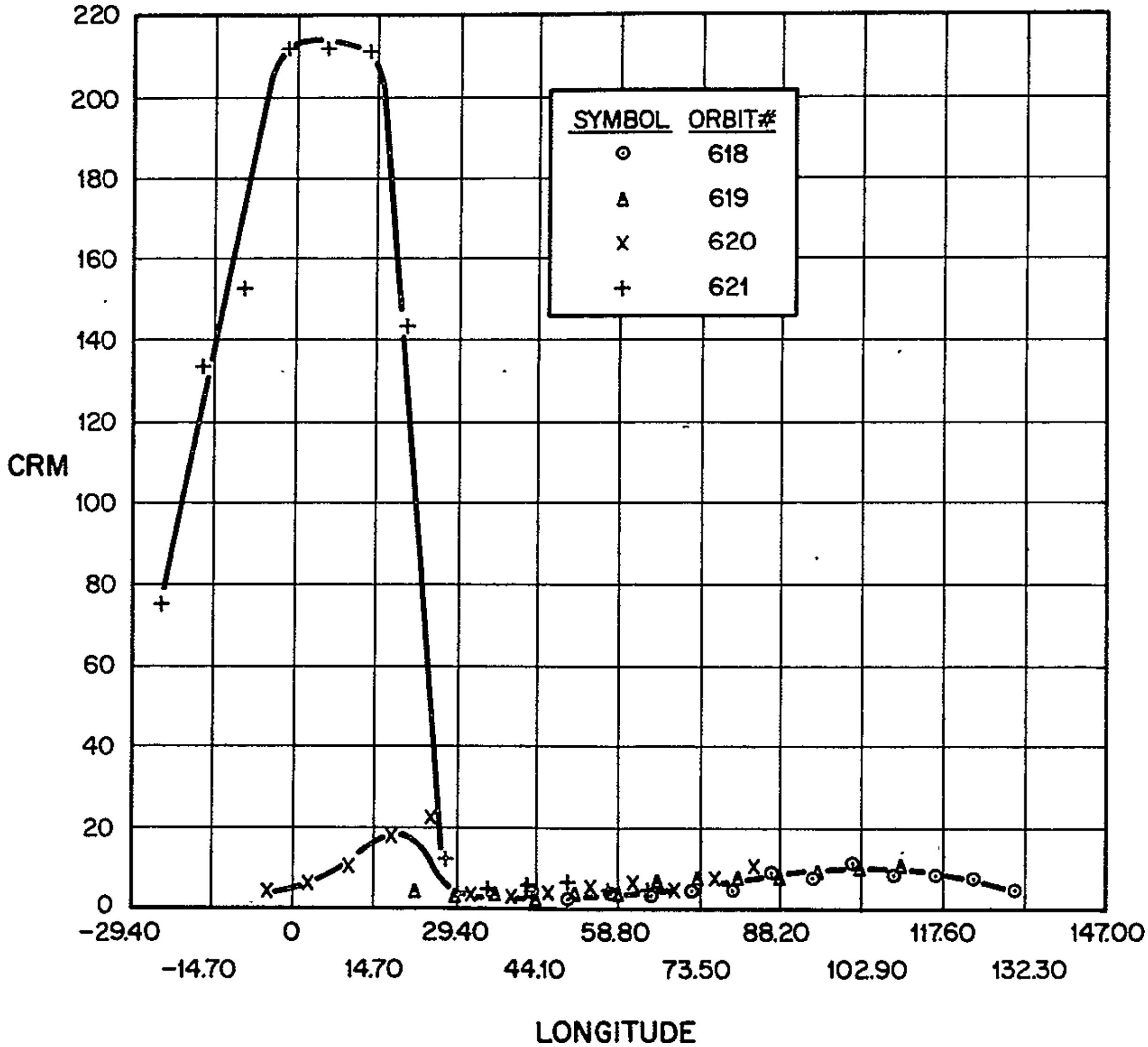
COUNT RATES — PHOTOELECTRIC DETECTOR



1816

Figure 7-3

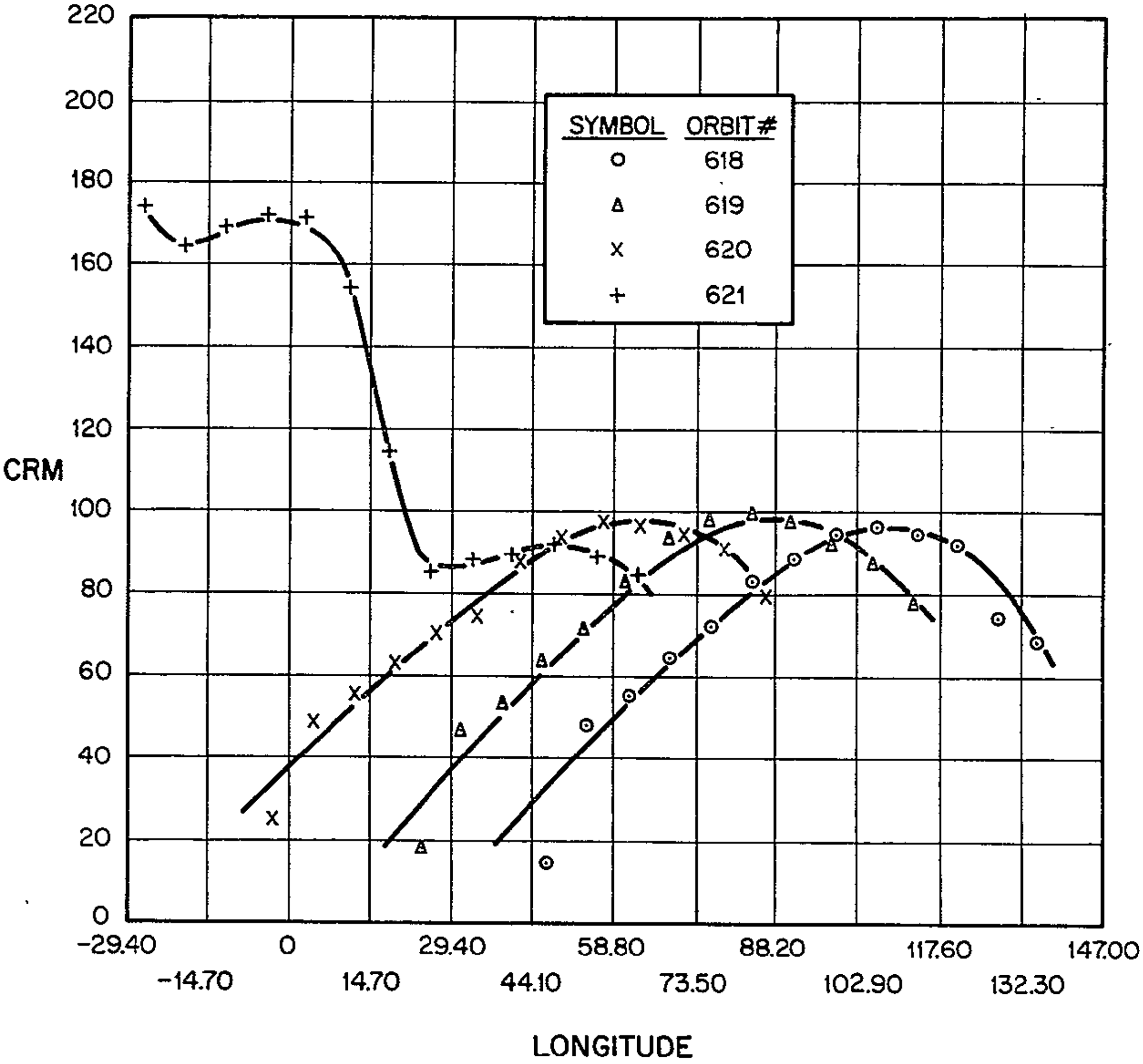
COUNT RATES — ANTHRACENE DETECTOR



1816

Figure 7-4

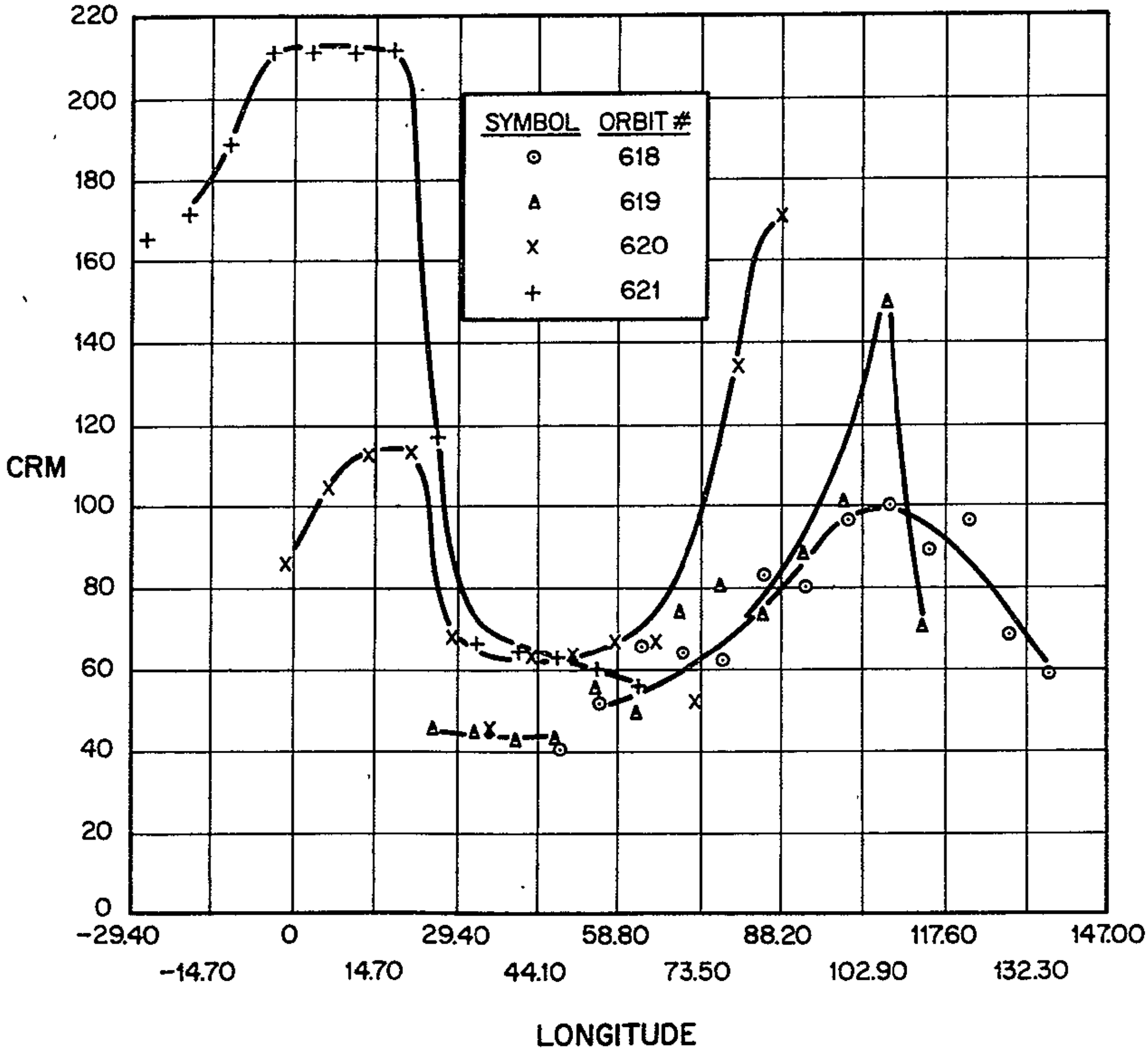
COUNT RATES — ANTICOINCIDENCE DETECTOR



1816

Figure 7-5

COUNT RATES — NaI DETECTOR



1816

Figure 7-6

REFERENCES

1. Giacconi, R., Reidy, W.P., Zehnpfennig, T., Lindsay, J.C. and Muney, W.S., Astrophys. J., 142, 1274 (1965).
2. Reidy, W.P., Vaiana, G.S., Zehnpfennig, T. and Giacconi, R., Astrophys. J., 151, 333 (1968).
3. Paolini, F.R., Giacconi, R., Manley. O., Reidy, W.P., Vaiana, G.S. and Zehnpfennig, T., Astron. J. Suppl., 73, June 1968.
4. Paolini, F.R., Giacconi, R., Krieger, A., Vaiana, G. and Webb, D., Bull. Am. Phys. Soc., 13, 1968.
5. Vaiana, G., Giacconi, R., Krieger, A., Paolini, F., Reidy, W.P., VanSpeybroeck, L. and Zehnpfennig, T., Bull. Am. Phys. Soc., 13, 1968.
6. Krieger, A.S. and Vaiana, G.S., Bull. Am. Astron. Soc., 1(3), 283 (1969).
7. Gursky, H. and Zehnpfennig, T., Appl. Opt, 5, 875 (1966).
8. Vaiana, G.S., Reidy, W.P., Zehnpfennig, T., VanSpeybroeck, L. and Giacconi, R., Science, 161, 564 (1968).
9. Vaiana, G.S. and Giacconi, R., Plasma Instabilities in Astrophysics, D.G. Wentzel and D.A. Tidman, Editors; Gordon and Breach, Publishers (1969).
10. Giacconi, R., Reidy, W.P., Vaiana, G.S., VanSpeybroeck, L., Zehnpfennig, T., Space Science Reviews, 9, 3(1969).
11. Zehnpfennig, T., Giacconi, R., Haggerty, R., Reidy, W.P. and Vaiana, G.S., "A Laboratory Program to Develop Improved Grazing Incidence X-ray Optics," NASA CR-717 (1967).
12. Henke, B.L., Elgin, R.L., Lent, R.E. and Ledingham, R.B., Norelco Reporter, 14, 112 (1967).
13. Lincke, R. and Wilkerson, T.D., Rev. Sci. Instr., 33(9), 911 (1962).
14. Lukirskii, A.P., Rumsh, M.A. and Karpovich, I.A., Optics and Spectroscopy, 9, 343 (1960).
15. Giacconi, R., Gursky, H., Paolini, F.R. and Rockwell, C., "Final Report for AS&E OSO-IV X-ray Pointed Telescope and Rotating X-ray Wheel Experiments"; ASE-1921; August 1968.

16. Chubb, T.A., Friedman, H., Kreplin, R.W. and Unzicker, A.E., Mem. Soc. Roy. Sci. Liege, 4, 228 (1961).

17. Solar Geophysical Data, Environmental Science Services Administration, U.S. Dept. of Commerce, 1967 and 1968.

18. Allen, C.W., Astrophysical Quantities, University of London, Athlone Press, 2nd Ed. (1964).

19. Culhane, J.L. and Phillips, K.J.H., "Solar X-ray Bursts at Energies Less Than 10 KEV Observed with OSO-IV." Univ. College of London; Mullard Space Science Lab. (1969).

20. Gabriel, A.H. and Jordan C., Mon. Not. R.A.S., 145, 241 (1969).

21. Teske, R.G., Solar Phys., 6, 193 (1969).

22. Drake, J.F., Gibson, J. and VanAllen, J., "Iowa Catalog of Solar X-ray Flux (2-12 Å)," University of Iowa, No. 69-36, July 1969.

23. Hudson, H.S., Peterson, L.E. and Schwartz, D.A., Astrophys. J., 157, 389 (1969).

24. Teske, R.G. and Thomas, R.J., Solar Phys., 8, 348 (1969).

25. Kundu, M.R., Solar Radio Astronomy, Interscience, New York (1965).

26. Wende, C.D., J. Geophys. Res., 74, 4649 (1969).

27. Donnelly, R.F., ESSA Technical Report ERL-81-SDL2 (1968).

28. Neupert, W.M., White, W.A., Gates, W.J., Swartz, M. and Young, R.M., Solar Phys., 6, 183 (1969).

29. Covington, A.E., Gagnon, H.P. and Moore, J.D., "Observations of Solar Flux at the Algonquin Radio Observatory on 2800 MC/S and at the Dominion Radio Astrophysical Observatory on 2700 MC/S," National Research Council of Canada, Radio and Electrical Engineering Division Report ERB-780, Ottawa, Can., January 1968.

30. Kawabata, K., Rept. Ionsph. Space Science, Japan, 14, 405 (1960).

31. Covington, A.E., Private Communication (1968).

APPENDIX

/* AS&E OSO-D PROGRAMS // GET RAW RASTERS */

```
                   /* AS&E OSO-D PROGRAMS // GET RAW RASTERS   */
  1                RWST.. PROCEDURE OPTIONS (MAIN),.
  2                DECLARE ILINEPIC PICTURE '99', ILINEOUT CHARACTER(2)
                            DEFINED ILINEPIC, COLID CHARACTER(80),.
  3                DECLARE RECID POINTER,.
  4                DECLARE  OUTAPE FILE RECORD SEQUENTIAL BUFFERED OUTPUT
                            ENVIRONMENT (V(3980) MEDIUM(SYS008, 2400) NOLABEL LEAVE
                            BUFFERS(2));
  5                DECLARE 01 RASTER EXTERNAL ALIGNED, 2(UTIME, UTIM05) FLOAT BINARY(53),
                            02 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                            JFWEEL, JAWEEL) FIXED BINARY(31), 02 (IRASRY(1920),
                            ISC05R(10), ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
  6                DECLARE (DATE, SDATE, YRDATE) FLOAT BINARY(53),.
  7                DECLARE ARRAY(27), ISUBSCR FIXED BINARY(31), KAY(40) CHARACTER(2),.
  8                DECLARE VOLTRAY(4) PICTURE '99', VCRAY(4) CHARACTER(2)
                            DEFINED VOLTRAY,.
  9                DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20),.
 10                DECLARE MONAME CHARACTER(4), SGN CHARACTER(1),.
 11                DECLARE (IFPRNTC, IFTAPEC) CHARACTER(1), (IFTAPE, IFPRNT) BIT(1),.
 12                DECLARE ISBEGN BIT(1),.
 13                DECLARE MESSAGE CHARACTER(50),.
 14                DECLARE (NTRAST, NXRAST, REWEPH, GETEPH, REWFIL, RUNFIL, SDAY, RUNEPH,
                            DEGDMS, FLTLUK, APTLUK, OSODLP, RUNTL) ENTRY;
 15                         INT2 = 2,.
 16                COLID = ' 1       5         10         15         20         25         30
                        35        40',.
 17                         CALL NTRAST,.
 18                         UTO = 39490,.
 19                         GET EDIT (UTBEGN, UTEND, IFPRNTC, IFTAPEC) (2F(15,5), 2A(1)),.
 20                         IF IFTAPEC = ' ' THEN IFTAPE='0'B,. ELSE DO,. IFTAPE = '1'B,.
 23                             CALL REWFIL (OUTAPE),. OPEN FILE (OUTAPE),. END,.
 26                         IF IFPRNTC = ' ' THEN IFPRNT = '0'B,. ELSE DO,. IFPRNT = '1'B,.
 29                             CALL REWEPH,. END,.
 31                         ISBEGN = '0'B,.
 32                NEXTRASTER.. CALL NXRAST,.
 33                         IF IEOF NE 0 THEN GO TO ENDFILERASTERS,.
 34                         IF UTIME LT UTBEGN THEN GO TO NEXTRASTER,.
 35                         IF UTIME GT UTEND THEN GO TO MAXTIMEXCEEDED,.
 36                         IF NOT ISBEGN THEN DO,. ISBEGN = '1'B,. UTLOTAPE = UTIME,.END,.
 40                         IF IFTAPE THEN WRITE FILE (OUTAPE) FROM (RASTER),.
 41                         UTHIGHTAPE = UTIME,.
 42                         IF NOT IFPRNT THEN GO TO NEXTRASTER,.
 43                         SDATE = UTIME + UTO,.
 44                         CALL SDAY (SDATE, IYEAR, YRDATE, MONTH, DATE, MONAME),.
 45                         IDATE1 = DATE,.
 46                         HRS = 24. * (DATE - IDATE1),.
 47                         CALL DEGDMS (HRS, ISGN, IHR, MIN, SECS),.
 48                         CALL FLTLUK (JFWEEL, FNAME, QLAM1, QLAM2, FNX, FEX),.
 49                         CALL APTLUK (JAWEEL, ANAME),.
                   /* GET ASPECT-EPHEMERIS DATA   */
 50                         CALL GETEPH (UTIME, ARRAY, SPRATE, ASPANG, ISDAY),.
```

```
/* AS&E OSO-D PROGRAMS // GET RAW RASTERS   */

  51                         DELT = OSODLP (UTIME, ARRAY),.
  52                         CALL NEWPAGE,.
  53                         SIDTIM = SIDGRN (UTIME + UTO),.
                     /* COMPUTE AND PRINT EPHEMERIS QUANTITIES    */
  54                         CELONG = ATAN (ARRAY(2), ARRAY(1)),.
  55                         TRLONG = (SIDTIM - CELONG) * 57.29578,.
  56                         TRLAT = ARRAY(22) * 57.29578,.
  57                         CLONGD = CELONG * 57.29578,.
  58                         PUT EDIT ('EPHEMERIS AT START OF SCAN', 'CELESTIAL LONGITUDE',
                                 CLONGD, ' DEGREES', 'POSITION VECTOR', ARRAY(1), ' KM')
                                 (SKIP(2), A, X(13), A, F(9,2), A, X(15), A, F(10,1), A),.
  59                         PUT EDIT ('TERRESTRIAL LONGITUDE', TRLONG, ARRAY(2),
                                 'GEODETIC LATITUDE', TRLAT, ARRAY(3),
                                 'GEODETIC ALTITUDE', ARRAY(23)) (SKIP, X(37), A, F(9,2),
                                 X(38), F(10,1), SKIP, X(41), A, F(9,2), X(38), F(10,1),
                                 SKIP, X(41), A, F(8,1)),.
  60                         RA = ATAN (ARRAY(20), ARRAY(19)) * 57.29578,.
  61                         ROLLA = ARRAY(27) * 57.29578,.
  62                         DEC = ASIN (ARRAY(21) ) * 57.29578,.
  63                         ALPHA = ARRAY(26) * 57.29578,.
  64                         PUT EDIT ('ASPECT AT START OF SCAN', 'PITCH ANGLE', ALPHA,
                                 ' DEGREES', 'SPIN AXIS', ARRAY(19), 'ROLL ANGLE', ROLLA,
                                 'UNIT VECTOR', ARRAY(20), 'RIGHT ASCENSION OF SPIN AXIS',
                                 RA, ARRAY(21), 'DECLINATION OF SPIN AXIS', DEC) (SKIP(2), A
                                 , X(24), A, F(9,2), A, X(22), A, F(11,7), SKIP, X(48), A,
                                 F(9,2), X(28), A, F(11,7), SKIP, X(30), A, F(9,2), X(39),
                                 F(11,7), SKIP, X(34), A, F(9,2)),.
  65                         SIDTIMD = SIDTIM * 57.29578,.
  66                         PUT EDIT ('SIDEREAL TIME AT START OF SCAN', SIDTIMD, ' DEGREES'
                                 , 'SOLAR', ARRAY(7), 'UNIT VECTOR', ARRAY(8), ARRAY(9))
                                 (SKIP(2), A, F(9,3), A, X(54), A, F(11,7), SKIP, X(95), A,
                                 F(11,7), SKIP, X(106), F(11,7)),.
                     /* PRINT STATISTICS  */
  67                         PUT EDIT (ISKPED, 'RASTER SCANS LOST DUE TO MISSING DATA',
                                 ISIZE, 'WORDS IN THIS RASTER SCAN', IBADCT,
                                 'QUESTIONABLE DATA WORDS IN THIS RASTER SCAN', IMISS,
                                 'MISSING DATA WORDS IN THIS RASTER SCAN') (SKIP, F(5,0),
                                 X(1), A),.
                     /* PRINT OUT SUBCOMMUTATOR VOLTAGE READINGS  */
  68                         IF ISUBSZ = 0 THEN GO TO NOSUBCOMS,.
  69                         PUT EDIT ('VOLTAGES FROM SAIL ANALOG SUBCOMMUTATOR', ISUBSZ,
                                 ' SETS', '05) 6 VOLT MONITOR', '07) 6 VOLT MONITOR',
                                 '27) NEGATIVE 6 VOLT SUPPLY', '44) 2.4 KV MONITOR')
                                 (SKIP(2), X(32), A, X(30), F(5,0), A, SKIP, X(13), A,
                                 X(12), A, X(4), A, X(11), A),.
  70                         DO I = 1 TO ISUBSZ,.
  71                         VCRAY = ' ',.
  72                         IF NOT ISCO5R(I) AND '00000001'B THEN VOLTRAY(1) = SUBSTR
                                 (ISCO5R(I), 9, 8),.
  73                         IF NOT ISCO7R(I) AND '00000001'B THEN VOLTRAY(2) = SUBSTR
                                 (ISCO7R(I), 9, 8),.
```

```
 74                    IF NOT ISC27R(I) AND '00000001'B THEN VOLTRAY(3) = SUBSTR
                           (ISC27R(I), 9, 8),.
 75                    IF NOT ISC44R(I) AND '00000001'B THEN VOLTRAY(4) = SUBSTR
                           (ISC44R(I), 9, 8),.
 76                    PUT EDIT (VCRAY) (SKIP, 4(X(28), A(2))),.
 77                    END,.
 78           CHECKRASTREND.. IF IENDN=1 THEN PUT EDIT('LAST RASTER BEFORE SUNSET')
                           (SKIP, A),.
 79                    IF IENDN = 2 THEN PUT EDIT
                           ('LAST RASTER BEFORE TIME DISCONTINUITY IN DATA') (SKIP(2),
                           A),.
 80                    CALL NEWPAGE,.
 81                    PUT EDIT (COLID) (SKIP(2), X(4), A(80)),.
 82                    DO M = 1 TO 48,.
 83                    ILINE = 49 - M,.
 84                    ILINEOUT = ' ',.
 85                    IF ILINE=1 OR ILINE=48 OR (ILINE/5)*5=ILINE THEN ILINEPIC
                           = ILINE,.
 86                    KAY = ' ',.
 87                    DO J = 1 TO 39 BY 2,.
 88                    ISUBSCR = 48 * (J-1) + 49 - M,.
 89                    CALL PROCWORD ( KAY(J)),.
 90                    ISUBSCR = 48 * J + M,.
 91                    CALL PROCWORD ( KAY(J+1)),.
 92                    END,.
 93                    PUT EDIT (ILINEOUT, KAY, ILINEOUT) (SKIP, A(2), X(2), 40A(2),
                           X(2), A(2)),.
 94                    END,.
 95                    PUT EDIT (COLID) (SKIP(2), X(4), A(80)),.
 96                    GO TO NEXTRASTER,.
 97           NOSUBCOMS.. PUT EDIT ('NO SUBCOM VOLTAGES AVAILABLE') (SKIP(2), A),.
 98                    GO TO CHECKRASTREND,.
 99           ENDFILERASTERS.. PUT EDIT ('END OF FILE ON TELEMETRY TAPE') (SKIP(2),
                           A),.
100                    GO TO WRAPUP,.
101           MAXTIMEXCEEDED.. PUT EDIT ('MAXIMUM REQUESTED TIME EXCEEDED ON TELEMETR
              Y TAPE') (SKIP(2), A),.
102           WRAPUP.. CALL RUNTL,.
103                    IF IFPRNT THEN CALL RUNEPH,.
104                    IF NOT IFTAPE THEN STOP,.
105                    CLOSE FILE (OUTAPE),.
106                    CALL RUNFIL (OUTAPE),.
107                    MESSAGE = ' ',.
108                    PUT STRING(MESSAGE) EDIT ('"OSO-D RAW RASTERS FROM', UTLOTAPE,
                           ' TO', UTHIGHTAPE, '"') (A, F(10,3), A, F(10,3)),.
109                    DISPLAY ('LABEL OUTPUT TAPE ON SYS009 AS FOLLOWS'),.
110                    DISPLAY (MESSAGE),.
111                    STOP,.
112           ASIN.. PROCEDURE (X),.
113                    RETURN (ATAN (X / SQRT (1. - X * X))),.
114           END,.
```

/* AS&E OSO-D PROGRAMS // GET RAW RASTERS   */

```
 115          NEWPAGE.. PROCEDURE,.
 116                  PUT EDIT ('RAW RASTER SCAN STARTING AT UT', MONAME,
                          IDATE1, ',', IYEAR, '   UT TIME', IHR, MIN, SECS,
                          UTIME) (PAGE, A, X(2), A, F(3,0), A, F(5,0), A, 2F(3,0),
                          F(6,2), X(10), F(10,3)),.
 117                  PUT EDIT (FNAME, 'LAMBDA 1 =', QLAM1, 'LAMBDA 2=', QLAM2,
                          'KN =', FNX, '/EPSILON      KE =', FEX, '/EPSILON',ANAME)
                          (SKIP, A, X(6), A, F(6,2), X(4), A, F(6,2), X(5), A,
                          F(8,2), A, F(8,2), A, SKIP, A),.
 118                  RETURN,.
 119          END,.
 120          PROCWORD.. PROCEDURE (OUTSTR),.
 121          DECLARE N, OUTSTR CHARACTER(2),.
 122                  OUTSTR = ' ',.
 123                  IF ISUBSCR GT ISIZE THEN DO,. OUTSTR = '==',. RETURN,. END,.
 127                  IF IRASRY (ISUBSCR) AND '00000001'B THEN DO,. OUTSTR='++',.
 129                      RETURN,.  END,.
 131                  N = SUBSTR (IRASRY(ISUBSCR), 9, 8),.
 132                  CALL INTHEX(N, INT2, OUTSTR),.
 133                  RETURN,.
 134          END,.
 135          END,.
```

```
STMT LEVEL NEST
                       /* AS&E OSO-D PROGRAMS // GET BACKGROUND RASTERS    */
  1                    BKGR:  PROCEDURE OPTIONS (MAIN);
  2      1             DECLARE ILINEPIC PICTURE '99', ILINEOUT CHARACTER(2)
                                 DEFINED ILINEPIC, COLID CHARACTER(80);
  3      1             DECLARE (INDEX, I) FIXED BINARY(31);
  4      1             DECLARE PREMNS FIXED DECIMAL(3,1);
  5      1             DECLARE MESSAGE CHARACTER(50);
  6      1             DECLARE SUMTAB(1800), SUMTAB4(1800), (MSUNTAB(1800), MSUNTAB4(1800))
                                 BIT(8);
  7      1             DECLARE MTEMP FIXED BINARY(8);
  8      1             DECLARE IF40MIL BIT(1);
  9      1             DECLARE MRAY(1920) FIXED DECIMAL(3,0);
 10      1             DECLARE RECID POINTER;
 11      1             DECLARE 1 OUTRECD BASED(RECID), 2(EPS, UTSTRT1, UTSTOP1, XNBARCAL,
                                 DELCAL, XN40CAL, DEL40CAL, XN40ONE, DEL40ONE,
                                 BAKRAY(1920) FIXED DECIMAL(3,1));
 12      1             DECLARE OUTFIL FILE RECORD SEQUENTIAL BUFFERED OUTPUT
                                 ENVIRONMENT (V(3884));
 13      1             DECLARE 01 RASTER EXTERNAL ALIGNED, 2 (UTIME,UTIM05) FLOAT BINARY(53),
                                 02 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                                 JEWEEL, JAWEEL) FIXED BINARY(31), 02 (IRASRY(1920),
                                 ISC05R(10), ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16);
 14      1             DECLARE (DATEA, SDATE, YRDATE) FLOAT BINARY(53);
 15      1             DECLARE ISBEGN BIT(1), ISBEGN1 BIT(1);
 16      1             DECLARE (MONAM1, MONAM2) CHARACTER(4), SGN CHARACTER(1);
 17      1             DECLARE KKAY(40) CHARACTER(2);
 18      1             DECLARE NBAR FIXED BINARY(8);
 19      1             DECLARE SUMRAY(1920);
 20      1             DECLARE ISGN CHARACTER(2);
 21      1             DECLARE (MHISUNWD, MHISUNWD4, I40CAL) FIXED BINARY(31,0);
 22      1             DECLARE (IYEAR1, IYEAR2, MONTH) FIXED BINARY(17);
 23      1             ON ERROR SNAP SYSTEM;
 24      1             COLID = '01        05           10           15           20           25           30
                              35        40';
 25      1                   CALL NTRAST;
 26      1                   UTORG = 291.;
 27      1                   UTO = 39490.;
 28      1                   ISBEGN1 = '0'B;
 29      1                   ISBEGN = '0'B;
 30      1                   OPEN FILE (OUTFIL);
 31      1                   IENDN = 0;
 32      1                   GET LIST (UTSTRT, UTEND, TDIF);
 33      1                   IF UTEND <= UTSTRT |  TDIF <= 0 THEN DO;  PUT EDIT
 35      1    1                    ('ILLEGAL INPUT PARAMETERS') (SKIP, A);  STOP;  END;
 38      1                   UTSTOP = UTSTRT + TDIF;
 39      1                   CALL NITCOUNTS;
 40      1             NEXTRASTER:  IENDNB4 = IENDN;
 41      1                   CALL NXRAST;
 42      1             TESTRASTER:  IF IEOF ¬= 0 THEN GO TO ENDOFFILE;
 44      1                   IF UTIME <  UTSTRT THEN GO TO NEXTRASTER;
 46      1                   IF UTIME >  UTSTOP THEN GO TO ENDTIMEINTERVAL;
```

```
        /* AS&E OSO-D PROGRAMS // GET BACKGROUND RASTERS     */


STMT LEVEL NEST

  49      1                   IF ¬    ISBEGN1 THEN DO;  ISBEGN1 = '1'B; UTSTRT=UTIME;  END;
  53      1                   IF IFNDNB4 = 1 THEN GO TO NEXTRASTER;
  55      1                   IF IENDN = 1 THEN ISIZE = ISIZE - 80;
  57      1                   IF JFWEEL ¬= 3 THEN GO TO SUNRASTER;
                  /* THIS IS A CALIBRATION RASTER */
  59      1                   MTOT = MTOT + 1;
  60      1                   IF ISIZE <  960 THEN DO;  MSMALL = MSMALL + 1;  GO
  64      1     1                TO NEXTRASTER;  END;
  65      1                   IF IMISS >  100 THEN DO;  MMISS = MMISS + 1;  GO
  69      1     1                TO NEXTRASTER;  END;
  70      1                   IF IBADCT >  100 THEN DO;  MHORR = MHORR + 1;  GO
  74      1     1                TO NEXTRASTER;  END;
                  /* DETERMINE AVERAGE COUNT DURING 1ST 20 LINES  */
  75      1                   IDENOM = 0;
  76      1                   SUM20 = 0.;
  77      1                   DO I = 5 TO 960;
  78      1     1             IF IRASRY(I) &   '00000011'B THEN GO TO ENDLOOP;
  80      1     1             NBAR = SUBSTR(IRASRY(I), 9);
  81      1     1             SUM20 = SUM20 + NBAR;
  82      1     1             IDENOM = IDENOM + 1;
  83      1     1     ENDLOOP:  END;
  84      1                   IF SUM20 / IDENOM >  5 THEN DO;  MNOISC = MNOISC + 1;  GO
  88      1     1                TO NEXTRASTER;  END;
  89      1                   MMSTOT = MMSTOT + IMISS;
  90      1                   M = M + 1;
  91      1                   MBADCT = MBADCT + IBADCT;
  92      1                   IF ISIZE >  1920 THEN ISIZE = 1920;
  94      1                   DO I = 1 TO ISIZE;
  95      1     1             IF IRASRY(I) &   '00000011'B THEN GO TO ENDLOOP1;
  97      1     1             NBAR = SUBSTR(IRASRY(I), 9);
  98      1     1             IF NBAR >= 20 THEN DO;  MHIWD = MHIWD + 1;  GO TO ENDLOOP1;
 102      1     2                END;
 103      1     1             SUMRAY(I) = SUMRAY(I) + NBAR;
 104      1     1             MRAY(I) = MRAY(I) + 1;
 105      1     1     ENDLOOP1:  END;
 106      1                   GO TO NEXTRASTER;
 107      1           SUNRASTER:  IF JAWEEL >  4 THEN GO TO NEXTRASTER;
 109      1                   IF JAWEEL = 1 |  JAWEEL = 4 THEN IF40MIL = '1'B;  ELSE IF40MIL
                                 ='0'B;
 112      1                   IF ISIZE <  96 THEN GO TO NEXTRASTER;
 114      1                   MTEMP = 0;
 115      1                   THISAV = 0;
 116      1                   DO J = 1 TO 19 BY 2;
 117      1     1             INDEX = 48 * J;
 118      1     1             CALL TREATSUNWORD;
 119      1     1             INDEX = 48 * J + 1;
 120      1     1             CALL TREATSUNWORD;
 121      1     1             INDEX = 48 * (J-1) + 1;
 122      1     1             CALL TREATSUNWORD;
```

```
STMT LEVEL NEST

123    1    1            INDEX = 48 * (J+1);
124    1    1            CALL TREATSUNWORD;
125    1    1            END;
126    1                 IF MTEMP <= 0 THEN GO TO NEXTRASTER;
128    1                 IF IF40MIL THEN GO TO SUNRASTER4;
130    1                 M10TOT = M10TOT + 1;
131    1                 IF M10TOT > 1800 THEN SIGNAL ERROR;
133    1                 SUMTAB(M10TOT) = THISAV;
134    1                 MSUNTAB(M10TOT) = MTEMP;
135    1                 GO TO NEXTRASTER;
136    1         SUNRASTER4:  M40TOT = M40TOT + 1;
137    1                 IF M40TOT > 1800 THEN SIGNAL ERROR;
139    1                 SUMTAB4(M40TOT) = THISAV;
140    1                 MSUNTAB4(M40TOT) = MTEMP;
141    1                 GO TO NEXTRASTER;
                 /* END OF TIME INTERVAL REACHED   */
142    1         ENDTIMEINTERVAL:  IF ISBEGN  THEN GO TO PRINTSTATISTICS;
144    1                 IF MTOT ¬= 0 THEN GO TO PRINTSTATISTICS;
146    1                 IF ISBEGN1 THEN GO TO ENDGROUP;
148    1                 I = (UTIME - UTSTRT) / TDIF;
149    1                 UTSTOP = UTSTRT + (I+1) * TDIF;
150    1                 UTSTRT = UTIME;
151    1                 ISBEGN1 = '1'B;
152    1                 GO TO GETNEXTGROUP;
                 /* PRINT OUT STATISTICS ON BACKGROUND RASTERS  */
153    1         PRINTSTATISTICS:  SDATE = UTSTRT + UT0;
154    1                 IF ¬  ISBEGN THEN DO;  ISBEGN = '1'B;  UTBEGN = UTSTRT;  END;
159    1                 ISBEGN = '1'B;
160    1                 CALL SDAY (SDATE, IYEAR1, YRDATE, MONTH, DATEA, MONAM1);
161    1                 IDAT1 = DATEA;
162    1                 HRS = 24. * (DATEA-IDAT1);
163    1                 CALL DEGDMS (HRS, ISGN, IHR1, MIN1, SECS1);
164    1                 SDATE = UTSTOP + UT0;
165    1                 CALL SDAY (SDATE, IYEAR2, YRDATE, MONTH, DATEA, MONAM2);
166    1                 IDAT2 = DATEA;
167    1                 HRS = 24. * (DATEA-IDAT2);
168    1                 CALL DEGDMS (HRS, ISGN, IHR2, MIN2, SECS2);
169    1                 CALL NEWPAGE;
170    1                 PUT EDIT (MTOT, 'CALIBRATION RASTERS') (SKIP(1), R(STATFORM));
171    1         STATFORM:  FORMAT(SKIP(1), F(5,0), X(1), A);
172    1                 PUT EDIT (MSMALL, 'HAD LESS THAN 20 LINES') (R(STATFORM));
173    1                 PUT EDIT (MMISS, 'HAD MORE THAN 100 INTERSPERSED MISSING WORDS'
                            ) (R(STATFORM));
174    1                 PUT EDIT (MHORR, 'HAD MORE THAN 100 QUESTIONABLE WORDS')
                            (R(STATFORM));
175    1                 PUT EDIT (MNOISC, 'HAD AVERAGE COUNT OF MORE THAN 5 IN 1ST 20 L
                 INES') (R(STATFORM));
176    1                 PUT EDIT (M, 'WERE USEABLE') (R(STATFORM));
177    1                 PUT EDIT (MMSTOT, 'MISSING WORDS', MBADCT, 'QUESTIONABLE WORDS'
```

```
STMT LEVEL NEST

                                , MHIWD, 'WORDS REJECTED BECAUSE COUNT GREATER THAN 20')
                                (R(STATFORM10));
178      1          STATFORM10:  FORMAT(SKIP(1), F(10,0), X(1), A);
179      1                    IF M = 0 THEN GO TO ENDGROUP;
181      1                    LOCATE OUTRECD FILE(OUTFIL) SET(RECID);
182      1                    UTSTRT1 = UTSTRT;
183      1                    UTSTOP1 = UTSTOP;
184      1                    XN40CAL = 0.;
185      1                    I40CAL  = 0;
186      1                    DO J = 1 TO 19 BY 2;
187      1     1              INDEX = 48 * J;
188      1     1              CALL TREATBACKRWORD;
189      1     1              INDEX = INDEX + 1;
190      1     1              CALL TREATBACKRWORD;
191      1     1              INDEX = 48 * (J-1) + 1;
192      1     1              CALL TREATBACKRWORD;
193      1     1              INDEX = 48 * (J+1);
194      1     1              CALL TREATBACKRWORD;
195      1     1              END;
196      1                    IF I40CAL <= 0 THEN DO;  DEL40CAL = 0.;  XN40CAL = 0.;  END;
201      1                        ELSE DO;  DEL40CAL = SQRT(XN40CAL)/I40CAL;  XN40CAL
204      1     1                  = XN40CAL / I40CAL;  END;
205      1                    PUT EDIT ('N BAR 40 CAL =', XN40CAL,'DEL 40 CAL =', DEL40CAL)
                                (R(NBARCALFORM));
206      1          NBARCALFORM:  FORMAT (SKIP(2), A(19), F(12,4), X(10), A(19), F(12,4));
207      1                    CALL PROCSUN ('10', M10TOT, MHISUNWD, SUMTAB, MSUNTAB);
208      1                    IF IDENOM ¬= 0 THEN GO TO PRINTNBAR40ONE;
210      1                    CALL PROCSUN ('40', M40TOT, MHISUNWD4, SUMTAB4, MSUNTAB4);
211      1          PRINTNBAR40ONE:  PUT EDIT ('N BAR 40 ONE =', XN40ONE, 'DEL 40 ONE =',
                                DEL40ONE) (R(NBARCALFORM));
212      1                    XNBARCAL = XN40CAL - XN40ONE;
213      1                    DELCAL = SQRT (DEL40CAL * DEL40CAL + DEL40ONE*DEL40ONE);
214      1                    PREMNS = 0.;
215      1                    DO I = 1 TO 1920;
216      1     1              IF MRAY(I) >  0 THEN BAKRAY(I) = SUMRAY(I) / MRAY(I) - XNBARCAL
218      1     1                  + PREMNS + .05  /* ROUND TO 0.1  */;   ELSE BAKRAY(I) =0;
219      1     1              PREMNS = 0.;
220      1     1              IF BAKRAY(I) <  0 THEN DO;  PREMNS = BAKRAY(I);  BAKRAY(I)=0.;
224      1     2                  END;
225      1     1              END;
226      1                    EPS = XNBARCAL / 4.9 * EXP ((UTSTRT-UTORG)/1400.);
227      1                    PUT EDIT ('N BAR CAL =', XNBARCAL, 'DEL CAL =', DELCAL)
                                (R(NBARCALFORM));
228      1                        PUT EDIT ('EPSILON =', EPS) (R(NBARCALFORM));
229      1                    CALL NEWPAGE;
230      1                    PUT EDIT ('AVERAGE BACKGROUND RASTER', COLID) (SKIP(2), A,
                                SKIP(2), X(4), A(80));
231      1                    DO I = 1 TO 48;
232      1     1              ILINE = 49 - I;
```

```
STMT LEVEL NEST

233     1     1          ILINEOUT = ' ';
234     1     1          IF ILINE = 48 |  ILINE = 1 |  (ILINE/5)*5 = ILINE THEN ILINEPIC
                             = ILINE;
236     1     1          DO J = 1 TO 39 BY 2;
237     1     2          INDEX = 48 * (J-1) + 49 - I;
238     1     2          CALL CONVERTER(BAKRAY(INDEX), KKAY(J));
239     1     2          INDEX = 48 *J + I;
240     1     2          CALL CONVERTER(BAKRAY(INDEX), KKAY(J+1));
241     1     2          END;
242     1     1          PUT EDIT (ILINEOUT, KKAY, ILINEOUT) (SKIP, A(2), X(2), 40 A(2),
                             X(2), A(2));
243     1     1          END;
244     1                PUT EDIT (COLID) (SKIP, X(4), A(80));
245     1                LOCATE OUTRECD FILE (OUTFIL) SET (RECID);
246     1                EPS = 0.;
247     1                UTSTRT1 = 0;
248     1                UTSTOP1 = 0.;
249     1                XNBARCAL = 0.;
250     1                DELCAL = 0.;
251     1                XN40CAL = 0.;
252     1                DEL40CAL = 0.;
253     1                XN400NE = 0.;
254     1                DEL400NE = 0.;
255     1                BAKRAY = MRAY * 0.1;
256     1         ENDGROUP:  UTSTRT = UTSTOP;
257     1                UTSTOP = UTSTRT + TDIF;
258     1                IF IEOF ¬= 0 THEN GO TO WRAPEOF;
260     1         GETNEXTGROUP:  IF UTSTRT >= UTEND THEN GO TO MAXTIMEEXCEEDED;
262     1                IF UTSTOP >  UTEND THEN UTSTOP = UTEND + .01;
264     1                CALL NITCOUNTS;
265     1                GO TO TESTRASTER;
266     1         ENDOFILE:  UTSTOP =UTIME;
267     1                UTEND = UTIME;
268     1                GO TO PRINTSTATISTICS;
269     1         MAXTIMEEXCEEDED:  PUT EDIT ('MAXIMUM REQUESTED TIME OF ', UTEND,
                             ' EXCEEDED') (SKIP(2), A, F(12,3), A);
270     1                GO TO WINDUP;
271     1         WRAPEOF:  PUT EDIT ('END OF FILE ENCOUNTERED ON INPUT TAPE') (SKIP(2),
                             A);
272     1         WINDUP:  CALL RUNTL;
273     1                CLOSE FILE (OUTFIL);
274     1                DISPLAY ('LABEL TAPE OUTFIL AS FOLLOWS --');
275     1                PUT STRING (MESSAGE) EDIT ('"OSO-D BACKGROUND RASTERS FROM ',
                             UTBEGN, ' TO ', UTEND, '"') (A, F(7,2), A, F(7,2));
276     1                DISPLAY (MESSAGE);
277     1                STOP;
278     1         TREATBACKRWORD:  PROCEDURE;
279     2                IF INDEX <= 4 THEN RETURN;
281     2                XN40CAL = XN40CAL + SUMRAY(INDEX);
```

```
STMT LEVEL NEST

282      2                  I40CAL = I40CAL + MRAY(INDEX);
283      2                  RETURN;
284      2          END;
285      1          TREATSUNWORD:  PROCEDURE;
286      2                  IF INDEX <= 4 |  INDEX >  ISIZE THEN RETURN;
288      2                  IF IRASRY(INDEX) &   '00000011'B THEN RETURN;
290      2                  NBAR = SUBSTR(IRASRY(INDEX), 9);
291      2                  IF NBAR >= 10 THEN GO TO HIGHWORD;
293      2                  THISAV = THISAV + NBAR;
294      2                  MTEMP = MTEMP + 1;
295      2                  RETURN;
296      2          HIGHWORD:  IF IF40MIL THEN MHISUNWD4 = MHISUNWD4 + 1;  ELSE MHISUNWD
                               =MHISUNWD + 1;
299      2                  RETURN;
300      2          END;
301      1          NITCOUNTS:  PROCEDURE;
302      2                  MHORR = 0;
303      2                  MMSTOT = 0;
304      2                  MNOISC = 0;
305      2                  MMISS = 0;
306      2                  MSMALL = 0;
307      2                  MBADCT = 0;
308      2                  MTOT = 0;
309      2                  M = 0;
310      2                  MRAY = 0;
311      2                  SUMRAY = 0.;
312      2                  MHIWD = 0;
313      2                  M10TOT = 0;
314      2                  MHISUNWD = 0;
315      2                  M40TOT = 0;
316      2                  MHISUNWD4 = 0;
317      2                  RETURN;
318      2          END;
319      1          NEWPAGE:  PROCEDURE;
320      2                  PUT EDIT ('TIME INTERVAL FROM ', MONAM1, IDAT1, ',', IYEAR1,
                                IHR1, MIN1, SECS1, ' TO ', MONAM2, IDAT2, ',', IYEAR2,
                                IHR2, MIN2, SECS2, '(', UTSTRT, ' TO', UTSTOP, ')' )
                               (PAGE, 2A, F(3,0), A, F(4,0), 2F(3,0), F(8,4), A, A, F(3,0)
                                , A, F(4,0), 2F(3,0), F(8,4), X(16), 2(A,F(8,3)),A);
321      2                  RETURN;
322      2          END;
323      1          CONVERTER:  PROCEDURE (X, KAY);
324      2          DECLARE KAY CHARACTER(2), X FIXED DECIMAL (3,1), PIC PICTURE '99V9';
325      2          DECLARE CTEMP CHARACTER(3), IPIC;
326      2                  PIC = X;
327      2                  CTEMP = PIC;
328      2                  IPIC = TRUNC(X);
329      2                  KAY = SUBSTR (CTEMP, 2, 2);
330      2                  IF IPIC <= 9 THEN RETURN;
```

```
STMT LEVEL NEST

332    2                IPIC = IPIC - 9;
333    2                IF IPIC >  26 THEN DO;  KAY = '**';  RETURN;  END;
338    2                SUBSTR(KAY,1,1)=SUBSTR('ABCDEFGHIJKLMNOPQRSTUVWXYZ$$',IPIC,1);
339    2                RETURN;
340    2         END;
341    1         PROCSUN:  PROCEDURE (ID, MTOT, MHISUNWD, SUMTAB, MSUNTAB);
342    2         DECLARE ID CHARACTER(2), SUMTAB(600), MSUNTAB(600) BIT(8);
343    2         DECLARE I, MTEMP FIXED BINARY(8);
344    2         DECLARE (IDENOM, MHISUNWD) FIXED BINARY(31,0);
345    2                M1OREJECTED = 0;
346    2                XN40ONE = 0.;
347    2                IDENOM = 0;
348    2                DO I = 1 TO MTOT;
349    2     1          MTEMP = MSUNTAB(I);
350    2     1          IF SUMTAB(I) / MTEMP >  XN40CAL THEN DO;  M1OREJECTED
353    2     2              =M1OREJECTED+1;  GO TO ENDLOOP2;  END;
355    2     1          IDENOM = IDENOM + MTEMP;
356    2     1          XN40ONE = XN40ONE + SUMTAB(I);
357    2     1   ENDLOOP2:  END;
358    2                PUT EDIT (MTOT, ID, ' MIL RASTERS PROCESSED', M1OREJECTED, ID,
                            ' MIL RASTERS REJECTED BECAUSE AVERAGE TOO HIGH', MHISUNWD,
                            ID, ' MIL RASTER WORDS REJECTED BECAUSE HIGHER THAN 10')
                            (SKIP, F(10,0), X(1), 2A);
359    2                PUT EDIT (IDENOM, ID, ' MIL RASTER WORDS USED')
                            (SKIP, F(10,0), X(1), 2A);
360    2                IF IDENOM <= 0 THEN DO;  DEL40ONE = 0.;  XN40ONE = 0.;  END;
365    2                    ELSE DO;  DEL40ONE = SQRT(XN40ONE)/IDENOM;  XN40ONE
368    2     1              = XN40ONE / IDENOM;  END;
369    2                RETURN;
370    2         END;
371    1         END;
```

```
              /* AS&E OSO-D PROGRAMS // GET CORRECTED RASTERS  */
  1           CRST.. PROCEDURE OPTIONS (MAIN),.
  2           DECLARE ILINEPIC PICTURE '99', ILINEOUT CHARACTER(2)
                      DEFINED ILINEPIC, COLID CHARACTER(80),.
  3           DECLARE RECID POINTER,.
  4           DECLARE 1 INRECD BASED(RECID) ALIGNED, 2(EPS, UTSTRT, UTSTOP, XNBARCAL,
                      DELCAL, XN40CAL, DEL40CAL, XN400NE, DEL400NE,
                      BAKRAY(1920) FIXED DECIMAL (3,1)),.
  5           DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                      ENVIRONMENT (V(3884) MEDIUM (SYS008, 2400) NOLABEL),.
  6           DECLARE 01 RASTER EXTERNAL ALIGNED, 2(UTIME, UTIM05) FLOAT BINARY(53),
                      02 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                      JFWEEL, JAWEEL) FIXED BINARY(31), 02 (IRASRY(1920),
                      ISC05R(10), ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
  7           DECLARE (DATEA, SDATE, YRDATE) FLOAT BINARY(53),.
  8           DECLARE ARRAY(27), ISUBSCR FIXED BINARY(31), KAY(40) CHARACTFR(2),.
  9           DECLARE TWOSQRBAK (1920),.
 10           DECLARE NBAR FLOAT,.
 11           DECLARE VOLTRAY(4) PICTURE '99', VCRAY(4) CHARACTER(2)
                      DEFINED VOLTRAY,.
 12           DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20),.
 13           DECLARE MONAME CHARACTER(4), SGN CHARACTER(1),.
 14           DECLARE PRTALLCHAR CHARACTER(1), IFPRTALL BIT(1),.
 15           ON ENDFILE (INTAPE) GO TO ENDBACKGROUND,.
 16           COLID = '01       05         10         15         20         25         30
                   35       40',.
 17                   CALL NTRAST,.
 18                   UTO = 39490,.
 19                   CALL REWEPH,.
 20                   OPEN FILE (INTAPE),.
 21                   GET EDIT (UTBEGN, UTEND, PRTALLCHAR) (2F(15,5), A(1)),.
 22                   IF PRTALLCHAR NE ' ' THEN IFPRTALL = '1'B,.ELSE IFPRTALL='0'B,.
 24                   UTIMF = -100.E40,.
 25                   GO TO FIRSTBACKGROUND,.
 26           NEXTBACKGROUND.. READ FILE (INTAPE) SET (RECID),.
 27           FIRSTBACKGROUND.. READ FILE (INTAPE) SET (RECID),.
 28                   IF UTSTOP LT UTBEGN THEN GO TO NEXTBACKGROUND,.
 29                   IF UTSTOP - UTSTRT LT 0.25 THEN GO TO NEXTBACKGROUND,.
 30                   IF UTSTRT GT UTEND + 0.25 THEN GO TO BACKGROUNDTIMEHI,.
 31                   TWOSQRBAK = 2. * SQRT (BAKRAY),.
 32                   GO TO TESTRASTIME,.
 33           NEXTRASTER.. CALL NXRAST,.
 34                   IF IEOF NE 0 THEN GO TO ENDFILERASTERS,.
 35           TESTRASTIME.. IF UTIME LT UTSTRT - 0.25 THEN GO TO NEXTRASTER,.
 36                   IF UTIME LT UTBEGN THEN GO TO NEXTRASTER,.
 37                   IF UTIME GT UTSTOP THEN GO TO NEXTBACKGROUND,.
 38                   IF UTIME GT UTEND THEN GO TO MAXTIMEXCEEDED,.
 39                   IF JFWEEL = 3 THEN GO TO NEXTRASTER,.
 40                   IF IFPRTALL THEN GO TO GUDRASTER,.
 41                   IGUDCNT = 0,.
 42                   DO I = 5 TO ISIZE,.
```

```
/* AS&E OSO-D PROGRAMS // GET CORRECTED RASTERS  */

 43                       IF IRASRY(I) AND '00000001'B THEN GO TO ENDLOOP,.
 44                       CALL PTWRDC (IRASRY, I, N, NBAR),.
 45                       IF NBAR - BAKRAY(I) LT TWOSQRBAK(I) THEN GO TO ENDLOOP,.
 46                       IGUDCNT = IGUDCNT + 1,.
 47                       IF IGUDCNT GE 7 THEN GO TO GUDRASTER,.
 48               ENDLOOP.. END,.
 49                       GO TO NEXTRASTER,.
 50               GUDRASTER.. SDATE = UTIME + UTO,.
 51                       CALL SDAY (SDATE, IYEAR, YRDATE, MONTH, DATEA, MONAME),.
 52                       IDATE1 = DATEA,.
 53                       HRS = 24. * (DATEA - IDATE1),.
 54                       CALL DEGDMS (HRS, ISGN, IHR, MIN, SECS),.
 55                       CALL FLTLUK (JFWFEL, FNAME, QLAM1, QLAM2, FNX, FFX),.
 56                       FN = FNX / EPS,.
 57                       FE = FEX  / EPS,.
 58                       CALL APTLUK (JAWEEL, ANAME),.
                  /* GET ASPECT-EPHEMERIS DATA   */
 59                       CALL GETEPH (UTIME, ARRAY, SPRATE, ASPANG, ISDAY),.
 60                       DELT = OSODLP (UTIME, ARRAY),.
 61                       CALL NEWPAGE,.
 62                       SIDTIM = SIDGRN (UTIME + UTO),.
                  /* COMPUTE AND PRINT EPHEMERIS QUANTITIES   */
 63                       CELONG = ATAN (ARRAY(2), ARRAY(1)),.
 64                       TRLONG = (SIDTIM - CELONG) * 57.29578,.
 65                       TRLAT = ARRAY(22) * 57.29578,.
 66                       CLONGD = CELONG * 57.29578,.
 67                       PUT EDIT ('EPHEMERIS AT START OF SCAN', 'CELESTIAL LONGITUDE',
                              CLONGD, ' DEGREES', 'POSITION VECTOR', ARRAY(1), ' KM')
                              (SKIP(2), A, X(13), A, F(9,2), A, X(15), A, F(10,1), A),.
 68                       PUT EDIT ('TERRESTRIAL LONGITUDE', TRLONG, ARRAY(2),
                              'GEODETIC LATITUDE', TRLAT, ARRAY(3),
                              'GEODETIC ALTITUDE', ARRAY(23)) (SKIP, X(37), A, F(9,2),
                              X(38), F(10,1), SKIP, X(41), A, F(9,2), X(38), F(10,1),
                              SKIP, X(41), A, F(8,1)),.
 69                       RA = ATAN (ARRAY(20), ARRAY(19)) * 57.29578,.
 70                       ROLLA = ARRAY(27) * 57.29578,.
 71                       DEC = ASIN (ARRAY(21) ) * 57.29578,.
 72                       ALPHA = ARRAY(26) * 57.29578,.
 73                       PUT EDIT ('ASPECT AT START OF SCAN', 'PITCH ANGLE', ALPHA,
                              ' DEGREES', 'SPIN AXIS', ARRAY(19), 'ROLL ANGLE', ROLLA,
                              'UNIT VECTOR', ARRAY(20), 'RIGHT ASCENSION OF SPIN AXIS',
                              RA, ARRAY(21), 'DECLINATION OF SPIN AXIS', DEC) (SKIP(2), A
                              , X(24), A, F(9,2), A, X(22), A, F(11,7), SKIP, X(48), A,
                              F(9,2), X(28), A, F(11,7), SKIP, X(30), A, F(9,2), X(39),
                              F(11,7), SKIP, X(34), A, F(9,2)),.
 74                       SIDTIMD = SIDTIM * 57.29578,.
 75                       PUT EDIT ('SIDEREAL TIME AT START OF SCAN', SIDTIMD, ' DEGREES'
                              , 'SOLAR', ARRAY(7), 'UNIT VECTOR', ARRAY(8), ARRAY(9))
                              (SKIP(2), A, F(9,3), A, X(54), A, F(11,7), SKIP, X(95), A,
                              F(11,7), SKIP, X(106), F(11,7)),.
 76                       PUT EDIT (ISKPED, 'RASTER SCANS LOST DUE TO MISSING DATA',
```

```
                              ISIZE, 'WORDS IN THIS RASTER SCAN', IBADCT,
                              'QUESTIONABLE DATA WORDS IN THIS RASTER SCAN', IMISS,
                              'MISSING DATA WORDS IN THIS RASTER SCAN') (SKIP, F(5,0),
                              X(1), A),.
                   /* PRINT OUT SUBCOMMUTATOR VOLTAGE READINGS  */
  77                       IF ISUBSZ = 0 THEN GO TO NOSUBCOMS,.
  78                       PUT EDIT ('VOLTAGES FROM SAIL ANALOG SUBCOMMUTATOR', ISUBSZ,
                              ' SETS', '05) 6 VOLT MONITOR', '07) 6 VOLT MONITOR',
                              '27) NEGATIVE 6 VOLT SUPPLY', '44) 2.4 KV MONITOR')
                              (SKIP(2), X(32), A, X(30), F(5,0), A, SKIP, X(13), A,
                              X(12), A, X(4), A, X(11), A),.
  79                       DO I = 1 TO ISUBSZ,.
  80                       VCRAY = ' ',.
  81                       IF NOT ISC05R(I) AND '00000001'B THEN VOLTRAY(1) = SUBSTR
                              (ISC05R(I), 9, 8),.
  82                       IF NOT ISC07R(I) AND '00000001'B THEN VOLTRAY(2) = SUBSTR
                              (ISC07R(I), 9, 8),.
  83                       IF NOT ISC27R(I) AND '00000001'B THEN VOLTRAY(3) = SUBSTR
                              (ISC27R(I), 9, 8),.
  84                       IF NOT ISC44R(I) AND '00000001'B THEN VOLTRAY(4) = SUBSTR
                              (ISC44R(I), 9, 8),.
  85                       PUT EDIT (VCRAY) (SKIP, 4(X(28), A(2))),.
  86                       END,.
  87               CHECKRASTREND.. IF IENDN=1 THEN PUT EDIT('LAST RASTER BEFORE SUNSET')
                              (SKIP, A),.
  88                       IF IENDN = 2 THEN PUT EDIT
                              ('LAST RASTER BEFORE TIME DISCONTINUITY IN DATA') (SKIP(2),
                              A),.
  89                       CALL NEWPAGE,.
  90                       PUT EDIT (COLID) (SKIP(2), X(4), A(80)),.
  91                       DO M = 1 TO 48,.
  92                       ILINE = 49 - M,.
  93                       ILINEOUT = ' ',.
  94                       IF ILINE=1 OR ILINE=48 OR (ILINE/5)*5=ILINE THEN ILINEPIC
                              = ILINE,.
  95                       KAY = ' ',.
  96                       DO J = 1 TO 39 BY 2,.
  97                       ISUBSCR = 48 * (J-1) + 49 - M,.
  98                       CALL PROCWORD ( KAY(J)),.
  99                       ISUBSCR = 48 * J + M,.
 100                       CALL PROCWORD ( KAY(J+1)),.
 101                       END,.
 102                       PUT EDIT (ILINEOUT, KAY, ILINEOUT) (SKIP, A(2), X(2), 40A(2),
                              X(2), A(2)),.
 103                       END,.
 104                       PUT EDIT (COLID) (SKIP(2), X(4), A(80)),.
 105                       GO TO NEXTRASTER,.
 106               NOSUBCOMS.. PUT EDIT ('NO SUBCOM VOLTAGES AVAILABLE') (SKIP(2), A),.
 107                       GO TO CHECKRASTREND,.
 108               ENDBACKGROUND.. PUT EDIT ('END OF FILE ON BACKGROUND RASTER TAPE')
                              (SKIP(2), A),.
```

```
 109                     GO TO WRAPUP,.
 110            BACKGROUNDTIMEHI.. PUT EDIT ('MAXIMUM REQUESTED TIME EXCEEDED ON BACKGR
                OUND RASTER TAPE') (SKIP(2), A),.
 111                     GO TO WRAPUP,.
 112            ENDFILERASTERS.. PUT EDIT ('END OF FILE ON TELEMETRY TAPE') (SKIP(2),
                     A),.
 113                     GO TO WRAPUP,.
 114            MAXTIMEXCEEDED.. PUT EDIT ('MAXIMUM REQUESTED TIME EXCEEDED ON TELEMETR
                Y TAPE') (SKIP(2), A),.
 115            WRAPUP.. CALL RUNEPH,.
 116                     CALL RUNTL,.
 117                     CLOSE FILE (INTAPE),.
 118                     STOP,.
 119            ASIN.. PROCEDURE (X),.
 120                     RETURN (ATAN (X / SQRT (1. - X * X))),.
 121            END,.
 122            NEWPAGE.. PROCEDURE,.
 123                     PUT EDIT ('CORRECTED RASTER SCAN STARTING AT UT', MONAME,
                          IDATE1, ',', IYEAR, '   UT TIME', IHR, MIN, SECS,
                          '(', UTIME, ')') (PAGE, A, X(2), A, F(3,0), A, F(5,0), A,
                          2F(3,0), F(6,2), X(10), A, F(8,3), A),.
 124                     PUT EDIT (FNAME, 'LAMBDA 1 =', QLAM1, 'LAMBDA 2=', QLAM2,
                          'KN =', FN, 'KE =', FE) (SKIP, A, X(6), A, F(6,2), X(4),
                          A, F(6,2), X(5), A, F(8,2), X(5), A, F(8,2)),.
 125                     PUT EDIT (ANAME, 'EPSILON =', EPS, 'N BAR CAL =', XNBARCAL,
                          'DELTA =', DELT) (SKIP, A, X(10), A, F(7,2), X(10), A,
                          F(8,2), X(9), A, F(8,2)),.
 126                     RETURN,.
 127            END,.
 128            PROCWORD.. PROCEDURE (OUTSTR),.
 129            DECLARE OUTSTR CHARACTER(2), PIC PICTURE '9', NBAR FLOAT BINARY,.
 130            DECLARE N, CORRN, QLOG, QLOGTR, QLOGFR,.
 131            DECLARE ITEMP, IPIC,.
 132                     OUTSTR = '  ',.
 133                     IF ISUBSCR GT ISIZE THEN DO,. OUTSTR = '==',. RETURN,. END,.
 137                     IF IRASRY (ISUBSCR) AND '00000001'B THEN DO,. OUTSTR='++',.
 139                          RETURN,.  END,.
 141                     CALL PTWRDC (IRASRY, ISUBSCR, N, NBAR),.
 142                     CORRN = NBAR - BAKRAY(ISUBSCR),.
 143                     IF NOT IFPRTALL THEN IF CORRN LT TWOSQRBAK(ISUBSCR) THEN GO
                          TO SETSMALL,.
 144                     IF CORRN LT 1.0 THEN GO TO SETSMALL,.
 145                     QLOG = LOG2 (CORRN),.
 146                     QLOGTR = TRUNC (QLOG),.
 147                     QLOGFR = (QLOG - QLOGTR) * 10.,.
 148                     ITEMP = QLOGFR + 0.5,.
 149                     IPIC = QLOGTR + 1.0,.
 150                     IF ITEMP GT 9 THEN DO,. ITEMP = 0,. IPIC = IPIC + 1,. END,.
 154                     PIC = ITEMP,.
 155                     SUBSTR (OUTSTR, 2, 1) = PIC,.
 156                     IF IPIC GT 35 THEN DO,. OUTSTR='**',. RETURN,. END,.
```

```
160                   SUBSTR(OUTSTR,1,1)=SUBSTR('0123456789ABCDEFGHIJKLMNOPQRSTUVWXY'
                          , IPIC, 1),.
161                   RETURN,.
162          SETSMALL.. OUTSTR = '--',.
163                   RETURN,.
164          END,.
165          END,.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                /* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */
   1            SUBSUM.. PROCEDURE OPTIONS (MAIN),.
   2                 DECLARE ZILCH CHARACTER(1),.
   3                 DECLARE NUMDAY PICTURE '99',.
   4                 DECLARE MONTHNAME CHARACTER(4),.
   5                 DECLARE NUMPIC CHARACTER (7),.
   6                 DECLARE NFIRSTNO PICTURE '99',.
   7                 DECLARE UTIM2 FLOAT BINARY (53),.
   8                 DECLARE IBUF(1000),.
   9            DECLARE RECID POINTER ,.
  10            DECLARE 1 INRECD BASED(RECID) ALIGNED ,
                          2 (EPS, UTSTRT, UTSTOP, XNBARCAL, DELCAL, XN400CAL, DEL400CAL,
                             XN400NE, DEL400NE, BAKRAY(1920)) FIXED DECIMAL (3,1)) ,.
  11            DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                              ENVIRONMENT (V(3884) MEDIUM(SYS009,2400) NOLABEL LEAVE),.
  12            DECLARE 1 RASTER EXTERNAL ALIGNED, 2 (UTIME, UTIM05) FLOAT BINARY(53),
                          2 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                         JFWEEL, JAWEEL) FIXED BINARY(31), 2 (IRASRY(1920), ISC05R(10),
                         ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
  13            DECLARE (DATE, SDATE, YRDATE) FLOAT BINARY(53) ,.
  14            DECLARE NBAR FLOAT ,.
  15            DECLARE COPTYM FLOAT BINARY (53),.
  16            DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20), MONAME CHARACTER(4),
                        SGN CHARACTER(1) ,.
  17            DECLARE RADCO(2,10) ,.
  18            DECLARE CRDRDR FILE STREAM INPUT
                     ENVIRONMENT (F(80) MEDIUM(SYSIPT,1442)),.
  19            ON ENDFILE (CRDRDR) GO TO FINISH ,.
  20                 ON ENDFILE (INTAPE) GO TO ENDBG,.
  21            ON TRANSMIT (INTAPE) GO TO BADBG ,.
  22                 N = 1000,.
  23                 LDEV = 11,.
  24                 CALL PLOTS(IBUF(1),N,LDEV),.
  25                 CALL PLOT(0.0E0,-0.5E0,11B),.
  26                 ICOUNT = 0,.
  27                 INDEC = 15,.
  28                 IBETA = -1,.
  29                 LINT = 24,.
  30                      IPEN = -3,.
  31             CALL LGAXS(0.0E0,0.0E0,'COUNTS/140 MSEC',INDEC,10.0E0,90.0E0,10.0E1,
                   0.3E0),.
  32                 CALL NTRAST,.
  33                 UTO = 39490,.
  34                 CALL REWFIL (INTAPE),.
  35                 OPEN FILE (INTAPE),.
  36                 UTIME = -100.E40,.
  37                 DO IN = 1 TO 2 ,.
  38                 GET FILE (CRDRDR) EDIT (L,(RADCO(L,M) DO M=1 TO 10))
                        (COLUMN(1),F(2),10(X(2),F(4,3))),.
  39                   END,.
  40                 CALL CRDS ,.
```

```
/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

  41          CRDS..PROCEDURE ,.
  42                  GET FILE (CRDRDR) EDIT (DAYB,HRB,BMIN,DAYN,HRN,EMIN,IX,IY)
                     (SKIP, 2(X(5), F(3), X(3), F(2), X(2), F(2)), 2(X(5),F(2))) ,.
  43                  UBGN = DAYB + HRB/24.0 +(BMIN -1.)/1440.0   ,.
  44                  UEND = DAYN + HRN/24.0 +(EMIN +1.)/1440.0   ,.
  45                  END ,.
  46              CALL PRINFO ,.
  47              GO TO FSTBG ,.
  48            NXTBG.. READ FILE (INTAPE) SET (RECID) ,.
  49            FSTBG.. READ FILE (INTAPE) SET (RECID) ,.
  50            BGTM.. IF UTSTOP LT UBGN THEN GO TO NXTBG ,.
  51                  UTOT = UTSTOP -UTSTRT ,.
  52                  IF UTOT LT 0.334 THEN GO TO NXTBG ,.
  53                  IF UTSTRT GT UEND + 0.5  THEN GO TO RNGBG ,.
  54                  CALCO=(1.340*EXP((300.0-UTSTRT)/1400.0))/XNBARCAL,.
              /* PRINT OUT BG RASTER HEAD */
  55              PUT EDIT ('NEW BACKGROUND RASTER FROM ',UTSTRT,' TO ',UTSTOP,
                  'NBARCAL = ',XNBARCAL,' CALCO = ',CALCO) (SKIP(3),A,F(10,5),A,
                  F(10,5),SKIP,COLUMN(10),A,F(5,3),X(5),A,F(5,3)),.
              /*PRINT OUT INFO */
  56          PRINFO .. PROCEDURE ,.
  57                  PUT EDIT ('RING INTEGRATION OF (',IX, ',' ,IY, ') FROM ',
                          DAYB, HRB,' HRS  ', BMIN, ' MINS TO  ', DAYN, HRN,
                          ' HRS  ', EMIN, ' MINS') (PAGE,A,F(3),A,F(3),A ,2 F(4),A,
                          F(3), A,2 F(4), A, F(3), A) ,.
  58                  END ,.
              /*RAW RASTERS */
  59              GO TO TESTIM ,.
  60          NXTRST..CALL NXRAST,.
  61              IF IEOF NE 0 THEN GO TO NORST ,.
  62          TESTIM.. IF UTIME LT UBGN THEN GO TO NXTRST,.
  63                  IF UTIME GT UTSTOP THEN GO TO NXTBG,.
  64              IF UTIME GT UEND THEN GO TO SWITCH ,.
  65                  IF JFWEEL = 3 THEN GO TO NXTRST,.
  66                  IAWL = JAWEEL ,.
  67                  IF IAWL = 3 THEN IAWL = 2 ,.
  68                  IF IAWL = 4 THEN IAWL = 1 ,.
  69                  IF IAWL = 5 OR JFWEEL = 5 THEN GO TO NXTRST ,.
              /* PRINTOUT RASTER HEADING HERE */
  70              SDATE = UTIME + UTO,.
  71              CALL SDAY (SDATE,IYEAR,YRDATE,MONTH,DATE,MONAME),.
  72              IDATE1=DATE,.
  73              IYRDATE =YRDATE,.
  74              HRS = 24.* (DATE - IDATE1),.
  75              CALL DEGDMS (HRS,ISGN,IHR,MIN,SECS) ,.
  76              CALL FLTLUK (JFWEEL,FNAME,QLAM1,QLAM2,FNX,FEX),.
  77              CALL APTLUK (JAWEEL, ANAME) ,.
  78              PUT EDIT ('RASTER SCAN STARTING AT', MONAME, IDATE1, ',', IYEAR,
                      '   UT TIME', IHR, MIN, SECS, 'DAY NOTATION', UTIME)
                      (SKIP(3),A,X(2),A,F(3,0),A,F(5,0),A,2 F(3,0),F(6,2),X(5),A,
                      F(10,5)) ,.
```

```
/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

                    PUT EDIT (FNAME,ANAME) (SKIP, A, X(10), A) ,.
                    IF ISAV NE 1 THEN GO TO CONT ,.
                    ISAV=0 ,.
                    DO J = 1 TO 240 ,.
                        IRASRY(J) =IRASRY(J) OR '00000010'B ,.
                        END,.
               CONT..IF IFNDN = 1 THEN ISAVE = 1 ,.
                                  ELSE ISAV =0 ,.
                        INOG = IBADCT + IMISS ,.
                        IF INOG GE 100 THEN DO,.
                                            PUT EDIT ('BAD RASTER',UTIME)(A,F(11,7)),.
                                            GO TO NXTRST ,.
                                            END,.
                        ISUM = 0 ,.
                        DO JC = 10 TO 40 BY 10,.
                          DO JR = 1 TO 48,.
                             JNDX = 48*JC - JR + 1,.
                             IF IRASRY(JNDX) AND '00000011'B THEN GO TO NDLP,.
                             CALL PTWRDC(IRASRY,JNDX,NUM,NBAR) ,.
                             ISUM =ISUM + NBAR ,.
                    NDLP..END,.
                        END,.
                        IF ISUM GE 4000 THEN DO,.
                                       PUT EDIT('VAN A RASTER',UTIME) (A,F(11,7)),.
                                       END,.
                    IF ISIZE LT 500 THEN DO,.
                        PUT EDIT ('SHORT RASTER',UTIME) (A,F(11,7)),.
                        GO TO NXTRST,.
                        END,.
                    IF ISIZE LT 1920 THEN DO J = ISIZE -96 TO ISIZE ,.
                        IRASRY(J) = IRASRY(J) OR '00000010'B ,.
                        END ,.
                IF ISIZE LT 1920 THEN DO,.
                    IT = MOD(IX,2) ,.
                    IF IT = 1 THEN LOX = 48*(IX -1)+ IY ,.
                              ELSE LOX = 48*IX - IY + 1 ,.
                    IF LOX GE ISIZE - 96 THEN DO ,.
                        PUT EDIT ('INCOMPLETE RASTER ') (A) ,.
                        GO TO NXTRST ,.
                        END ,.
                END,.
               /* THIS IS THE RING INTEGRATION ROUTINE */
                    SUM = 0  ,.
                    SIGMA = 0 ,.
                    ITFLG = 10 ,.
                    DO N = 1 TO 10 ,.
                      LIM = N - 1 ,.
                      JX1 = IX - LIM ,.
                      JX2 = IX + LIM ,.
                      JY1 = IY - LIM ,.
                      JY2 = IY + LIM ,.
```

```
                    JDY2 = 2* LIM ,.
                    DEL = 0. ,.
                    NBAD = 0 ,.
                    RING = 0 ,.
                    BACK = 0 ,.
                    IF N = 1 THEN NBOX = 1 ,.
                              ELSE NBOX = 8*LIM ,.
                    DO JX = JX1 TO JX2 ,.
                      IF JX = JX1 OR JX = JX2 THEN JDY = 1 ,.
                                                   ELSE JDY = JDY2 ,.
                      IF JX LE 0 OR JX GT 40  THEN GO TO BADX ,.
                      JT = MOD(JX,2) ,.
                      DO JY = JY1 TO JY2 BY JDY ,.
                        IF JY LE 0 OR JY GT 48 THEN GO TO BADY ,.
                        IF JT = 1 THEN NDX=48*(JX - 1)+JY ,.
                                   ELSE NDX = 48*JX - JY +1 ,.
                        IF NDX GT ISIZE THEN GO TO BADY ,.
                        IF IRASRY(NDX) AND '00000011'B THEN GO TO BADY  ,.
                        CALL PTWRDC(IRASRY,NDX,NUM,NBAR) ,.
                        RING = RING + NBAR ,.
                        BACK = BACK + BAKRAY(NDX) ,.
                        GO TO NDYLP ,.
            BADY..      NBAD = NBAD+ 1 ,.
            NDYLP..     END ,.
                      GO TO NDXLP ,.
            BADX..    DO JY = JY1 TO JY2 BY JDY ,.
                        NBAD = NBAD + 1 ,.
                        END ,.
            NDXLP..   END ,.
                    CONTRIB = RING - BACK ,.
                    IF N GE 3 AND CONTRIB LE SQRT(BACK) THEN GO TO ENDIT ,.
                    BOX = NBOX ,.
                    BAD = NBAD ,.
                    IF BOX - BAD LE 0.9 THEN GO TO ENDIT ,.
                    GEOM = BOX/(BOX -BAD) ,.
                    DEL = GEOM * SQRT(RING + BACK) ,.
                    SUM = SUM + CONTRIB * GEOM  ,.
                    SIGMA = SQRT(SIGMA*SIGMA + DEL*DEL) ,.
                    GO TO NDNLP ,.
            ENDIT.. ITFLG = N-1 ,.
                    GO TO COMPUT ,.
            NDNLP..END ,.
            COMPUT..KR = ITFLG ,.
                  IF KR = 0 THEN KR = 1,.
                  FSUM = SUM*CALCO/RADCO(IAWL,KR) ,.
                  ERR = SIGMA*CALCO/RADCO(IAWL,KR) ,.
                  CORTYM = UTIME + IX*5.12/48/1440,.
                  ICOUNT = ICOUNT +1,.
                  IF ICOUNT = 1 THEN DO,.
                      UTIMELAST = CORTYM,.
                      NUTIM = CORTYM*24,.
```

/* AS&F OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                    UTIM2 = CORTYM,.
                    MONTHNAME = MONAME,.
                    NUMDAY = IDATE1,.
                    ZILCH = ' ',.
                    END,.
                IF FSUM LE 0.1E03 THEN DO,.
                XPAG = (CORTYM * 24 - NUTIM)*0.90,.
                CALL PLOT (XPAG,0.0E0,11B),.
                CALL PLOT (XPAG,0.28E0,10B),.
                GO TO COMPT1,.
                END,.
                XGFSUM = LOG10(FSUM),.
                XGFSUMHIGH = LOG10(FSUM+ERR),.
                XGFSUMLOW = LOG10(FSUM-ERR),.
                INTEQ = 0,.
                IF XGFSUM GT 5 THEN DO,.
                    XGFSUM = XGFSUM-3,.
                    XGFSUMHIGH = XGFSUMHIGH-3,.
                    XGFSUMLOW = XGFSUMLOW - 3,.
                    INTEQ = 6,.
                    END,.
                YPAG = (XGFSUM-2)*10/3,.
                YPAGLOW = (XGFSUMLOW-2)*10/3,.
                YPAGHIGH = (XGFSUMHIGH-2)*10/3,.
                IF JFWEEL = 2 & IAWL = 1 THEN INTEQ = INTEQ + 1 ,.
                IF JFWEEL = 4 & IAWL = 1 THEN INTEQ = INTEQ + 2 ,.
                IF JFWEEL = 1 & IAWL = 2 THEN INTEQ = INTEQ + 3 ,.
                IF JFWEEL = 2 & IAWL = 2 THEN INTEQ = INTEQ + 4 ,.
                IF JFWEEL = 4 & IAWL = 2 THEN INTEQ = INTEQ + 5 ,.
                DIFFER = (CORTYM - UTIMELAST)*24,.
                IF DIFFER GE 3 THEN DO,.
                    ICOUNT = 0,.
                  LASTONE..IDOWN = 2,.
                    IPEN = 3,.
            AXLEN = ((UTIMELAST*24) - NUTIM)*0.90 + 3.0,.
                    CALL PLOT(AXLEN,0.0E0,IPEN),.
                    CALL PLOT(0.0E0,0.0E0,IDOWN),.
                    NUMHRS = UTIMELAST*24 - NUTIM,.
                    NSTART1 = NUTIM/24,.
                    FIRSTNO = UTIM2 - NSTART1,.
                    NANAM = FIRSTNO*24,.
                    NFIRSTNO = NANAM,.
                    ISYMB = 13,.
                    ICHARNUM = 2,.
            DO J = 1 TO (NUMHRS + 3);
            XPAGHRS = (J-1)*0.90;
                CALL SYMBOL(XPAGHRS,10.0E0,0.07E0,ISYMB,0.0E0,ICODE),.
            END;
            DO J = 1 TO (NUMHRS + 3),.
                    XPAGHRS = (J-1)*0.90,.
                CALL SYMBOL(XPAGHRS,0.0E0,0.07E0,ISYMB,0.0E0,ICODE),.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
 231                    CALL SYMBOL(XPAGHRS,-0.14E0,0.10E0,NFIRSTNO,0.0E0,ICHARNUM),.
 232                    NANAM = NANAM + 1,.
 233                    IF NANAM GE 24 THEN  NANAM = NANAM - 24,.
 234                    NFIRSTNO = NANAM,.
 235                    END,.
 236                    NUMPIC = NUMDAY CAT ZILCH CAT MONTHNAME,.
 237                    NFXGL = 7,.
 238                    CALL SYMBOL(0.0F0,-0.4E0,0.07F0,NUMPIC,0.0E0,NFXGL),.
 239                IPEN = -3,.
 240           XPAGE = (UTIMELAST*24 - NUTIM)*0.90 + 5,.
 241                    IF ICOUNT NE 0 THEN GO TO VERYLAST,.
 242                    CALL PLOT(XPAGE,0.0F0,IPEN),.
 243            CALL LGAXS(0.0E0,0.0F0,'COUNTS/140 MSEC',INDEC,10.0F0,90.0E0,10.0F1,
               0.3E0),.
 244                    NUTIM = CORTYM*24,.
 245                END,.
 246                LASTONE2..XPAG = (CORTYM*24 - NUTIM)*0.90,.
 247                ICODE = -1,.
 248           IF YPAG GE 0.0E0 & YPAG LE 10.0E0 THEN
                    CALL SYMBOL(XPAG,YPAG,0.07E0,INTEQ,0.0F0,ICODE),.
 249                INTEP = 15,.
 250           XPG = XPAG - 0.017:
 251           IF YPAGHIGH GE 0.0F0 & YPAGHIGH LE 10.0F0 THEN
                    CALL SYMBOL(XPG,YPAGHIGH,0.07E0,INTEP,0.0E0,ICODE),.
 252            IF YPAGLOW LE 0.0 THEN GO TO TOOLOW,.
 253            IF YPAGLOW GE 10.0E0 THEN GO TO TOOLOW,.
 254                CALL SYMBOL(XPG,YPAGLOW,0.07E0,INTEP,0.0E0,ICODE),.
 255                TOOLOW..IF ISUM GE 4000 THEN DO,.
 256                    NVANALLENRASTER = 29,.
 257                    GUIDE = YPAGLOW - 0.10,.
 258           IF GUIDE GE 0.0E0 THEN
                    CALL SYMBOL(XPAG,GUIDE,0.07E0,NVANALLENRASTER,0.0E0,ICODE),.
 259                    END,.
 260                UTIMELAST = CORTYM,.
               /* NOW PRINT THE RESULT */
 261            COMPT1..PUT EDIT('INTEGRAL OVER ',KR,' RINGS = ',SUM,'SIGMA = ',SIGMA)
                            (SKIP   ,COLUMN(10),A,F(3),A,F(8,1),X(3),A,F(7,1)) ,.
 262                PUT EDIT ('CORRECTED VALUES---INTEGRAL = ',FSUM,'BRAC = ',ERR)
                            (COLUMN(10),A,F(8,1),X(2),A,F(7,1)) ,.
 263                GO TO NXTRST ,.
 264           SWITCH..CALL CRDS ,.
 265                CALL PRINFO ,.
 266                GO TO BGTM ,.
 267           ENDBG..PUT EDIT ('END OF FILE ON BACKGROUND TAPE') (PAGE, A) ,.
 268                GO TO FINISH ,.
 269           RNGBG..PUT EDIT ('BG TAPE READS START = ', UTSTART,'CARDS END AT',
                      USWCH) (PAGE, A, F(10,5), A, F(10,5)),.
 270                GO TO FINISH ,.
 271           BADBG..PUT EDIT ('BAD BG AT' ,UTSTRT) (SKIP(3),A,X(2),F(10,5)),.
 272                GO TO NXTBG,.
 273           NORST..PUT EDIT('END OF FILE ON TELEMETRY TAPE') (PAGE,A) ,.
```

```
/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

            FINISH..PUT EDIT ('PROGRAM TERMINATED INTERNALLY') (SKIP(3),A) ,.
                 GO TO LASTONE,.
                 VERYLAST..DO J = 1 TO 12,.
                    INTEQ = J - 1,.
                    YCOOR = 2.00 + 0.25*INTEQ,.
                    CALL SYMBOL(AXLEN,YCOOR,0.07E0,INTEQ,0.0E0,ICODE),.
                    END,.
                 NK = 25,.
                 SA = AXLEN + 0.3,.
                 CALL SYMBOL(SA,2.00E0,0.07E0,'MYLAR-4ARCMIN              ',0.0E0,NK),.
                 CALL SYMBOL(SA,2.25E0,0.07E0,'1/2MIL BE-4ARCMIN          ',0.0E0,NK),.
                 CALL SYMBOL(SA,2.50E0,0.07E0,'2MIL BE-4ARCMIN            ',0.0E0,NK),.
                 CALL SYMBOL(SA,2.75E0,0.07E0,'MYLAR-1ARCMIN              ',0.0E0,NK),.
                 CALL SYMBOL(SA,3.00E0,0.07E0,'1/2MIL BE-1ARCMIN          ',0.0E0,NK),.
                 CALL SYMBOL(SA,3.25E0,0.07E0,'2MIL BE-1ARCMIN            ',0.0E0,NK),.
                 CALL SYMBOL(SA,3.50E0,0.07E0,'MYLAR-4ARCMIN/1000         ',0.0E0,NK),.
                 CALL SYMBOL(SA,3.75E0,0.07E0,'1/2MIL BE-4ARCMIN/1000',0.0E0,NK),.
                 CALL SYMBOL(SA,4.00E0,0.07E0,'2MIL BE-4ARCMIN/1000 ',0.0E0,NK),.
                 CALL SYMBOL(SA,4.25E0,0.07E0,'MYLAR-1ARCMIN/1000    ',0.0E0,NK),.
                 CALL SYMBOL(SA,4.50E0,0.07E0,'1/2MIL BE-1ARCMIN/1000',0.0E0,NK),.
                 CALL SYMBOL(SA,4.75E0,0.07E0,'2MIL BE-1ARCMIN/1000  ',0.0E0,NK),.
                 IJKLMN = 24,.
                 CALL SYMBOL(SA,1.00E0,0.07E0,'V MEANS VAN ALLEN RASTER',0.0E0,
                      IJKLMN),.
                 IPEN = 999,.
            CALL PLOT(10.0E0,AXLEN,IPEN),.
                 PUT EDIT ('CALCOMP TAPE MADE')  (SKIP(3),A),.
                 CALL RUNTL ,.
                 CLOSE FILE (INTAPE) ,.
                 CALL RUNFIL (INTAPE) ,.
                 END ,.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                 /* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */
  1              SUBSUM.. PROCEDURE OPTIONS (MAIN),.
  2                   DECLARE IBUF(1000) FIXED BINARY,.
  3                   DECLARE MONAM1 CHARACTER (4),.
  4                   DECLARE DAYNUM PICTURE '99',.
  5                   DECLARE CHAR CHARACTER (7),.
  6                   DECLARE ZILCH CHARACTER (1),.
  7              DECLARE RECID POINTER ,.
  8              DECLARE 1 INRECD BASED(RECID) ALIGNED ,
                           2 (EPS, UTSTRT, UTSTOP, XNBARCAL, DELCAL, XN40CAL, DEL40CAL,
                              XN400NE, DEL400NE, BAKRAY(1920) FIXED DECIMAL (3,1)) ,.
  9              DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                               ENVIRONMENT (V(3884) MEDIUM(SYS009,2400) NOLABEL LEAVE),.
 10              DECLARE 1 RASTER EXTERNAL ALIGNED, 2 (UTIME, UTIM05) FLOAT BINARY(53),
                           2 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                          JFWEFL, JAWEFL) FIXED BINARY(31), 2 (IRASRY(1920), ISC05R(10),
                          ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
 11              DECLARE (DATE, SDATE, YRDATE) FLOAT BINARY(53) ,.
 12              DECLARE NBAR FLOAT ,.
 13              DECLARE ENAME CHARACTER(24), ANAME CHARACTER(20), MONAME CHARACTER(4),
                         SGN CHARACTER(1) ,.
 14              DECLARE RADCO(2,10) ,.
 15              DECLARE CRDRDR FILE STREAM INPUT
                      ENVIRONMENT (F(80) MEDIUM(SYSIPT,1442)),.
 16              ON ENDFILE (CRDRDR) GO TO FINISH ,.
 17                   ON ENDFILE (INTAPE) GO TO ENDBG,.
 18              ON TRANSMIT (INTAPE) GO TO BADBG ,.
 19                   N = 1000,.
 20                   LDEV = 11,.
 21                   CALL PLOTS(IBUF(1),N,LDEV),.
 22                   CALL PLOT(0.0E0,-0.5E0,11B),.
 23                    NCHAR = 17 ,.
 24                   CALL SYMBOL(0.75E0,10.0E0,0.15E0,'1/2 MIL BE FILTER',0.0E0,
                         NCHAR),.
 25                   INDEC = 15,.
 26                   IPEN = -3,.
 27                   IBETA = -1,.
 28                   LINT = 15,.
 29                CALL LGAXS (0.0E0,0.0E0,'COUNTS/140 MSEC',INDEC,10.0E0,90.0E0,1.0E2,
                 0.3E0),.
 30                   IB = 0,.
 31                   CALL NTRAST,.
 32                   UT0 = 39490,.
 33                   CALL REWFIL (INTAPE),.
 34                   OPEN FILE (INTAPE),.
 35                   UTIME = -100.E40,.
 36                   DO IN = 1 TO 2 ,.
 37                   GET FILE (CRDRDR) EDIT (L,(RADCO(L,M) DO M=1 TO 10))
                        (COLUMN(1),F(2),10(X(2),F(4,3))),.
 38                     END,.
 39                   CALL CRDS ,.
```

```
/* AS&E OSO-O PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

 40              CRDS..PROCEDURE ,.
 41                      GET FILE (CRDRDR) EDIT (DAYB,HRB,BMIN,DAYN,HRN,EMIN,IX,IY)
                        (SKIP, 2(X(5), F(3), X(3), F(2), X(2), F(2)), 2(X(5),F(2))) ,.
 42                      UBGN = DAYB + HRB/24.0 +(BMIN -1.)/1440.)    ,.
 43                      UEND = DAYN + HRN/24.0 +(EMIN +1.)/1440.0    ,.
 44                      END ,.
 45                  CALL PRINFO ,.
 46                  GO TO FSTBG ,.
 47                NXTBG.. READ FILE (INTAPE) SET (RECID) ,.
 48                FSTBG.. READ FILE (INTAPE) SET (RECID) ,.
 49                BGTM.. IF UTSTOP LT UBGN THEN GO TO NXTBG ,.
 50                       UTOT = UTSTOP -UTSTRT ,.
 51                       IF UTOT LT 0.334 THEN GO TO NXTBG ,.
 52                       IF UTSTRT GT UEND + 0.5  THEN GO TO RNGBG ,.
 53                       CALCO=(1.340*EXP((300.0-UTSTRT)/1400.0))/XNBARCAL,.
                /* PRINT OUT BG RASTER HEAD */
 54                 PUT EDIT ('NEW BACKGROUND RASTER FROM ',UTSTRT,' TO ',UTSTOP,
                    'NBARCAL = ',XNBARCAL,' CALCO = ',CALCO) (SKIP(3),A,F(10,5),A,
                    F(10,5),SKIP,COLUMN(10),A,F(5,3),X(5),A,F(5,3)),.
                /*PRINT OUT INFO */
 55             PRINFO .. PROCEDURE ,.
 56                      PUT EDIT ('RING INTEGRATION OF (',IX, ',' ,IY, ') FROM ',
                              DAYB, HRB,' HRS  ', BMIN, ' MINS TO  ', DAYN, HRN,
                              ' HRS  ',. EMIN, ' MINS') (PAGE,A,F(3),A,F(3),A ,2 F(4),A,
                              F(3), A,2 F(4), A, F(3), A) ,.
 57                      END ,.
                /*RAW RASTERS */
 58                 GO TO TESTIM ,.
 59             NXTRST..CALL NXRAST,.
 60                  IF IEOF NE 0 THEN GO TO NORST ,.
 61             TESTIM.. IF UTIME LT UBGN THEN GO TO NXTRST,.
 62                      IF UTIME GT UTSTOP THEN GO TO NXTBG,.
 63                  IF UTIME GT UEND THEN GO TO SWITCH ,.
 64                      IF JFWEEL = 3 THEN GO TO NXTRST,.
 65                      IAWL = JAWEEL ,.
 66                      IF IAWL = 3 THEN IAWL = 2 ,.
 67                      IF IAWL = 4 THEN IAWL = 1 ,.
 68                      IF IAWL = 5 OR JFWEEL = 5 THEN GO TO NXTRST ,.
                /* PRINTOUT RASTER HEADING HERE */
 69                  SDATE = UTIME + UTO,.
 70                  CALL SDAY (SDATE,IYEAR,YRDATE,MONTH,DATE,MONAME),.
 71                  IDATE1=DATE,.
 72                  IYRDATE =YRDATE,.
 73                  HRS = 24.* (DATE - IDATE1),.
 74                  CALL DEGDMS (HRS,ISGN,IHR,MIN,SECS) ,.
 75                  CALL FLTLUK (JFWEEL,FNAME,QLAM1,QLAM2,FNX,FEX),.
 76                  CALL APTLUK (JAWEEL, ANAME) ,.
 77                  PUT EDIT ('RASTER SCAN STARTING AT', MONAME, IDATE1, ',', IYEAR,
                        '   UT TIME', IHR, MIN, SECS, 'DAY NOTATION', UTIME)
                        (SKIP(3),A,X(2),A,F(3,0),A,F(5,0),A,2 F(3,0),F(6,2),X(5),A,
                        F(10,5)) ,.
```

```
/* AS&E DSP-0 PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

  78                    PUT EDIT (FNAME,ANAME) (SKIP, A, X(10), A) ,.
  79                    IF ISAV NE 1 THEN GO TO CONT ,.
  80                    ISAV=0 ,.
  81                    DO J = 1 TO 240 ,.
  82                        IRASRY(J) =IRASRY(J) OR '00000010'B ,.
  83                        END,.
  84              CONT..IF IENDN = 1 THEN ISAVE = 1 ,.
  85                                  ELSE ISAV =0 ,.
  86                        INOG = IBADCT + IMISS ,.
  87                        IF INOG GE 100 THEN DO,.
  88                                            PUT EDIT ('BAD RASTER',UTIME)(A,F(11,7)),.
  89                                            GO TO NXTRST ,.
  90                                            END,.
  91                        ISUM = 0 ,.
  92                        DO JC = 10 TO 40 BY 10,.
  93                          DO JR = 1 TO 48,.
  94                            JNDX = 48*JC - JR + 1,.
  95                            IF IRASRY(JNDX) AND '00000011'B THEN GO TO NDLP,.
  96                            CALL PTWRDC(IRASRY,JNDX,NUM,NBAR) ,.
  97                            ISUM =ISUM + NBAR ,.
  98                  NDLP..END,.
  99                        END,.
 100                        IF ISUM GE 4000 THEN DO,.
 101                                      PUT EDIT('VAN A RASTER',UTIME) (A,F(11,7)),.
 102                                      END,.
 103                  IF ISIZE LT 500 THEN DO,.
 104                        PUT EDIT ('SHORT RASTER',UTIME) (A,F(11,7)),.
 105                        GO TO NXTRST,.
 106                        END,.
 107                  IF ISIZE LT 1920 THEN DO J = ISIZE -96 TO ISIZE ,.
 108                        IRASRY(J) = IRASRY(J) OR '00000010'B ;.
 109                        END ,.
 110              IF ISIZE LT 1920 THEN DO,.
 111                  IT = MOD(IX,2) ,.
 112                  IF IT = 1 THEN LDX = 48*(IX -1)+ IY ,.
 113                            ELSE LDX = 48*IX - IY + 1 ,.
 114                  IF LDX GE ISIZE - 96 THEN DO ,.
 115                        PUT EDIT ('INCOMPLETE RASTER ') (A) ,.
 116                        GO TO NXTRST ,.
 117                        END ,.
 118              END,.
              /* THIS IS THE RING INTEGRATION ROUTINE */
 119                 SUM = 0  ,.
 120                 SIGMA = 0 ,.
 121                 ITFLG = 10 ,.
 122                 DO N = 1 TO 10 ,.
 123                   LIM = N - 1 ,.
 124                    JX1 = IX - LIM ,.
 125                    JX2 = IX + LIM ,.
 126                    JY1 = IY - LIM ,.
 127                    JY2 = IY + LIM ,.
```

```
/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

                    JDY2 = 2* LIM ,.
                    DEL = 0. ,.
                    NBAD = 0 ,.
                    RING = 0 ,.
                    BACK = 0 ,.
                    IF N = 1 THEN NBOX = 1 ,.
                              ELSE NBOX = 8*LIM ,.
                    DO JX = JX1 TO JX2 ,.
                      IF JX = JX1 OR JX = JX2 THEN JDY = 1 ,.
                                                ELSE JDY = JDY2 ,.
                      IF JX LE 0 OR JX GT 40  THEN GO TO BADX ,.
                      JT = MOD(JX,2) ,.
                      DO JY = JY1 TO JY2 BY JDY ,.
                        IF JY LE 0 OR JY GT 48 THEN GO TO BADY ,.
                        IF JT = 1 THEN NDX=48*(JX - 1)+JY ,.
                                  ELSE NDX = 48*JX - JY +1 ,.
                        IF NDX GT ISIZE THEN GO TO BADY ,.
                        IF IRASRY(NDX) AND '00000011'B THEN GO TO BADY ,.
                        CALL PTWRDC(IRASRY,NDX,NUM,NBAR) ,.
                        RING = RING + NBAR ,.
                        BACK = BACK + BAKRAY(NDX) ,.
                        GO TO NDYLP ,.
              BADY..    NBAD = NBAD+ 1 ,.
              NDYLP..   END ,.
                      GO TO NDXLP ,.
              BADX..  DO JY = JY1 TO JY2 BY JDY ,.
                        NBAD = NBAD + 1 ,.
                        END ,.
              NDXLP..  END ,.
                    CONTRIB = RING - BACK ,.
                    IF N GE 3 AND CONTRIB LE SQRT(BACK) THEN GO TO ENDIT ,.
                    BOX = NBOX ,.
                    BAD = NBAD ,.
                    IF BOX - BAD LE 0.9 THEN GO TO ENDIT ,.
                    GEOM = BOX/(BOX -BAD) ,.
                    DEL = GEOM * SQRT(RING + BACK) ,.
                    SUM = SUM + CONTRIB * GEOM  ,.
                    SIGMA = SQRT(SIGMA*SIGMA + DEL*DEL) ,.
                    GO TO NONLP ,.
              ENDIT.. ITFLG = N-1 ,.
                    GO TO COMPUT ,.
              NONLP..END ,.
              COMPUT..KP = ITFLG ,.
                   FSUM = SUM*CALCO/RADCO(IAWL,KP) ,.
                   ERR = SIGMA*CALCO/RADCO(IAWL,KP) ,.
                   CORTYM = UTIME + IX*5.12/48/1440,.
                   SAMPL..IF JENEFL NE 2 THEN GO TO COMPTL,.
                   IB = IB +1,.
                   IF IB = 1 THEN DO,.
                      MONAML = MONAME,.
                      IDATL = IDATEL,.
```

```
/* AS&E OSO-O PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

 179                  DAYNUM = IDATI,.
 180                  ZILCH = ' ',.
 181                  CHAR = MONAMI CAT ZILCH CAT DAYNUM,.
 182              NCHAR = 7,.
 183              CALL SYMBOL(0.0E0,-0.4E0,0.07E0,CHAR,0.0E0,NCHAR),.
 184              IUBGN = CORTYM,.
 185                  END,.
 186              IOMEGA = 3,.
 187              IF IAWL = 2 THEN IOMEGA = 4,.
 188              IF FSUM LE 0.1E03 THEN DO,.
 189          XCORD = 2.0*(CORTYM - IUBGN ),.
 190          CALL PLOT (XCORD,0.0E0,11B),.    CALL PLOT (XCORD,0.20E0,10B),.
 192           GO TO COMPT1,.      END,.
 194              FSUM0 = LOG10(FSUM),.
 195              IMP = 0,.
 196              IF FSUM0 GT 5.0 THEN DO,.
 197                  FSUM0 = FSUM0 - 3,.
 198                  IMP = 1,.
 199                  END,.
 200              YCOOR = (FSUM0-2)*10/3,.
 201              XCOOR = (CORTYM - IUBGN)*2.0,.
 202              ICODE = -1,.
 203              CALL SYMBOL(XCOOR,YCOOR,0.07E0,IOMEGA,0.0E0,ICODE),.
 204              IF IMP = 1 THEN DO,.
 205              VN = YCOOR + 0.2,.
 206                  LINDEX = 62,.
 207                  CALL SYMBOL(XCOOR,VN,0.07E0,LINDEX,0.0E0,ICODE),.
 208                  END,.
 209              IF FSUM GE 4000 THEN DO,.
 210                  NVN = 29,.
 211                  YCOOR = YCOOR - 0.10,.
 212                  CALL SYMBOL(XCOOR,YCOOR,0.07E0,NVN,0.0E0,ICODE),.
 213                  END,.
          /* NOW PRINT THE RESULT */
 214       COMPT1..PUT EDIT('INTEGRAL OVER ',KR,' RINGS = ',SUM,'SIGMA = ',SIGMA)
                      (SKIP    ,COLUMN(10),A,F(3),A,F(8,1),X(3),A,F(7,1)) ,.
 215              PUT EDIT ('CORRECTED VALUES---INTEGRAL = ',FSUM,'BRAC = ',ERR)
                          (COLUMN(10),A,F(8,1),X(2),A,F(7,1)) ,.
 216              GO TO NXTRST ,.
 217      SWITCH..CALL CRDS ,.
 218              CALL PRINFO ,.
 219              GO TO BGTM ,.
 220      ENDBG..PUT EDIT ('END OF FILE ON BACKGROUND TAPE') (PAGE, A) ,.
 221              GO TO FINISH ,.
 222      RNGBG..PUT EDIT ('BG TAPE READS START = ', UTSTART,'CARDS END AT',
                  USWCH) (PAGE, A, F(10,5), A, F(10,5)),.
 223              GO TO FINISH ,.
 224      BADBG..PUT EDIT ('BAD BG AT' ,UTSTRT) (SKIP(3),A,X(2),F(10,5)),.
 225              GO TO NXTBG,.
 226      NDRST..PUT EDIT('END OF FILE ON TELEMETRY TAPE') (PAGE,A) ,.
 227      FINISH..PUT EDIT ('PROGRAM TERMINATED INTERNALLY') (SKIP(3),A) ,.
```

```
/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

 228                    AXLEN = 30.0E0    ,.
 229                    BGNN = IUBGN * 1.0E00    ,.
 230                   CALL AXIS(0.0E0,0.0E0,'UTIME  IN  DAYS',-INDEC,30.0E0,0.0E0,BGNN,
                         0.5E00),.
 231                     DO JKL = 1 TO 30,.
 232                    FUDGE = JKL*1.0E0,.  CALL PLOT(FUDGE,10.0E0,118),.  CALL PLOT(FUDGE,
 235                  9.80E0,108),.      END,.
 236                      SA = AXLEN + 1.0,.      IOMEGA = 3,.
 238                      CALL SYMBOL(SA,4.0E0,0.07E0,IOMEGA,0.0E0,ICODE),.
 239                      CALL SYMBOL(SA,4.5E0,0.07E0,IOMEGA,45.0E0,ICODE),.
 240                      SAS = SA + 0.5,.
 241                      CALL SYMBOL(SAS,4.0E0,0.07E0,'4ARCMIN',0.0E0,NCHAR),.
 242                      CALL SYMBOL(SAS,4.5E0,0.07E0,'1ARCMIN',0.0E0,NCHAR),.
 243                      NUMB = 43,.
 244                      CALL SYMBOL(SAS,3.0E0,0.07E0,
                           'ARROW-DIVISION BY 1000; V--VAN ALLEN RASTER',0.0E0,NUMB),.
 245                      IPEN = 999,.
 246                      CALL PLOT(0.0E0,0.0E0,IPEN),.
 247                      PUT EDIT ('CALCOMP TAPE MADE') (SKIP(3),A),.
 248                      CALL PUNTL  ,.
 249                      CLOSE FILE (INTAPE) ,.
 250                      CALL PUNFIL (INTAPE) ,.
 251                      END ,.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                /* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */
  1             SUBSUM.. PROCEDURE OPTIONS (MAIN),.
  2                  DECLARE IBUF(1000) FIXED BINARY,.
  3                  DECLARE MONAM1 CHARACTER (4),.
  4                  DECLARE DAYNUM PICTURE '99',.
  5                  DECLARE CHAR CHARACTER (7),.
  6                  DECLARE ZILCH CHARACTER (1),.
  7             DECLARE RECID POINTER ,.
  8             DECLARE 1 INRECD BASED(RECID) ALIGNED ,
                          2 (EPS, UTSTRT, UTSTOP, XNBARCAL, DELCAL, XN40CAL, DEL40CAL,
                             XN40ONE, DEL40ONE, BAKRAY(1920) FIXED DECIMAL (3,1)) ,.
  9             DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                              ENVIRONMENT (V(3884) MEDIUM(SYS009,2400) NOLABEL LEAVE),.
 10             DECLARE 1 RASTER EXTERNAL ALIGNED, 2 (UTIME, UTIM05) FLOAT BINARY(53),
                          2 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                         JFWEEL, JAWEFL) FIXED BINARY(31), 2 (IRASRY(1920), ISC05R(10),
                         ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
 11             DECLARE (DATE, SDATE, YRDATE) FLOAT BINARY(53) ,.
 12             DECLARE NBAR FLOAT ,.
 13             DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20), MONAME CHARACTER(4),
                        SGN CHARACTER(1) ,.
 14             DECLARE RADCO(2,10) ,.
 15             DECLARE CRDRDR FILE STREAM INPUT
                     ENVIRONMENT (F(80) MEDIUM(SYSIPT,1442)),.
 16             ON ENDFILE (CRDRDR) GO TO FINISH ,.
 17                  ON ENDFILE (INTAPE) GO TO ENDBG,.
 18             ON TRANSMIT (INTAPE) GO TO BADBG ,.
 19                  N = 1000,.
 20                  LDEV = 11,.
 21                  CALL PLOTS(IBUF(1),N,LDEV),.
 22                  CALL PLOT(0.0E0,-0.5E0,11B),.
 23                   NCHAR = 17 ,.
 24                  CALL SYMBOL(0.75E0,10.0E0,0.15E0,'1/2 MIL BE FILTER',0.0E0,
                        NCHAR),.
 25                  INDEC = 15,.
 26                  IPEN = -3,.
 27                  IBETA = -1,.
 28                  LINT = 15,.
 29              CALL LGAXS (0.0E0,0.0E0,'COUNTS/140 MSEC',INDEC,10.0E0,90.0E0,1.0E2,
                 0.3E0),.
 30                  IB = 0,.
 31                  CALL NTRAST,.
 32                  UTO = 39490,.
 33                  CALL REWFIL (INTAPE),.
 34                  OPEN FILE (INTAPE),.
 35                  UTIME = -100.E40,.
 36                  DO IN = 1 TO 2 ,.
 37                  GET FILE (CRDRDR) EDIT (L,(RADCO(L,M) DO M=1 TO 10))
                        (COLUMN(1),F(2),10(X(2),F(4,3))),.
 38                    END,.
 39                  CALL CRDS ,.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
  40              CKDS..PROCEDURE ,.
  41                    GET FILE (CRDRDR) EDIT (DAYB,HRB,BMIN,DAYN,HRN,EMIN,IX,IY)
                       (SKIP, 2(X(5), F(3), X(3), F(2), X(2), F(2)), 2(X(5),F(2))) ,.
  42                    UBGN = DAYB + HRB/24.0 +(BMIN -1.)/1440.0    ,.
  43                    UEND = DAYN + HRN/24.0 +(EMIN +1.)/1440.0    ,.
  44                    END ,.
  45                 CALL PRINFO ,.
  46                 GO TO FSTBG ,.
  47               NXTBG.. READ FILE (INTAPE) SET (RECID) ,.
  48               FSTBG.. READ FILE (INTAPE) SET (RECID) ,.
  49               BGTM.. IF UTSTOP LT UBGN THEN GO TO NXTBG ,.
  50                    UTOT = UTSTOP -UTSTRT ,.
  51                    IF UTOT LT 0.334 THEN GO TO NXTBG ,.
  52                    IF UTSTRT GT UEND + 0.5  THEN GO TO RNGBG ,.
  53                    CALCO=(1.340*EXP((300.0-UTSTRT)/1400.0))/XNBARCAL,.
                  /* PRINT OUT BG RASTER HEAD */
  54                 PUT EDIT ('NEW BACKGROUND RASTER FROM ',UTSTRT,' TO ',UTSTOP,
                     'NBARCAL = ',XNBARCAL,' CALCO = ',CALCO) (SKIP(3),A,F(10,5),A,
                     F(10,5),SKIP,COLUMN(10),A,F(5,3),X(5),A,F(5,3)),.
                  /*PRINT OUT INFO */
  55              PRINFO .. PROCEDURE ,.
  56                    PUT EDIT ('RING INTEGRATION OF (',IX, ',' ,IY, ') FROM ',
                              DAYB, HRB,' HRS  ', BMIN, ' MINS TO  ', DAYN, HRN,
                              ' HRS  ', EMIN, ' MINS') (PAGE,A,F(3),A,F(3),A ,2 F(4),A,
                              F(3), A,2 F(4), A, F(3), A) ,.
  57                    END ,.
                  /*RAW RASTERS */
  58                 GO TO TESTIM ,.
  59              NXTRST..CALL NXRAST,.
  60                 IF IEOF NE 0 THEN GO TO NORST ,.
  61              TESTIM.. IF UTIME LT UBGN THEN GO TO NXTRST,.
  62                    IF UTIME GT UTSTOP THEN GO TO NXTBG,.
  63                 IF UTIME GT UEND THEN GO TO SWITCH ,.
  64                    IF JFWEEL = 3 THEN GO TO NXTRST,.
  65                    IAWL = JAWEEL ,.
  66                    IF IAWL = 3 THEN IAWL = 2 ,.
  67                    IF IAWL = 4 THEN IAWL = 1 ,.
  68                    IF IAWL = 5 OR JFWEEL = 5 THEN GO TO NXTRST ,.
                  /* PRINTOUT RASTER HEADING HERE */
  69                 SDATE = UTIME + UT0,.
  70                 CALL SDAY (SDATE,IYEAR,YRDATE,MONTH,DATE,MONAME),.
  71                 IDATE1=DATE,.
  72                 IYRDATE =YRDATE,.
  73                 HRS = 24.* (DATE - IDATE1),.
  74                 CALL DEGDMS (HRS,ISGN,IHR,MIN,SECS) ,.
  75                 CALL FLTLUK (JFWEEL,FNAME,QLAM1,QLAM2,FNX,FEX),.
  76                 CALL APTLUK (JAWEEL, ANAME) ,.
  77                 PUT EDIT ('RASTER SCAN STARTING AT', MONAME, IDATE1, ',', IYEAR,
                        '   UT TIME', IHR, MIN, SECS, 'DAY NOTATION', UTIME)
                        (SKIP(3),A,X(2),A,F(3,0),A,F(5,0),A,2 F(3,0),F(6,2),X(5),A,
                        F(10,5)) ,.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
 78                  PUT EDIT (FNAME,ANAME) (SKIP, A, X(10), A) ,.
 79                  IF ISAV NE 1 THEN GO TO CONT ,.
 80                  ISAV=0 ,.
 81                  DO J = 1 TO 240 ,.
 82                      IRASRY(J) =IRASRY(J) OR '00000010'B ,.
 83                      END,.
 84             CONT..IF IENDN = 1 THEN ISAVE = 1 ,.
 85                            ELSE ISAV =0 ,.
 86                      INOG = IBADCT + IMISS ,.
 87                      IF INOG GE 100 THEN DO,.
 88                                  PUT EDIT ('BAD RASTER',UTIME)(A,F(11,7)),.
 89                                  GO TO NXTRST ,.
 90                                  END,.
 91                      ISUM = 0 ,.
 92                      DO JC = 10 TO 40 BY 10,.
 93                        DO JR = 1 TO 48,.
 94                          JNDX = 48*JC - JR + 1,.
 95                          IF IRASRY(JNDX) AND '00000011'B THEN GO TO NDLP,.
 96                          CALL PTWRDC(IRASRY,JNDX,NUM,NBAR) ,.
 97                          ISUM =ISUM + NBAR ,.
 98                  NDLP..END,.
 99                      END,.
100                      IF ISUM GE 4000 THEN DO,.
101                                PUT EDIT('VAN A RASTER',UTIME) (A,F(11,7)),.
102                                END,.
103                  IF ISIZE LT 500 THEN DO,.
104                      PUT EDIT ('SHORT RASTER',UTIME) (A,F(11,7)),.
105                      GO TO NXTRST,.
106                      END,.
107                  IF ISIZE LT 1920 THEN DO J = ISIZE -96 TO ISIZE ,.
108                      IRASRY(J) = IRASRY(J) OR '00000010'B ,.
109                      END ,.
110              IF ISIZE LT 1920 THEN DO,.
111                  IT = MOD(IX,2) ,.
112                  IF IT = 1 THEN LDX = 48*(IX -1)+ IY ,.
113                         ELSE LDX = 48*IX - IY + 1 ,.
114                  IF LDX GE ISIZE - 96 THEN DO ,.
115                      PUT EDIT ('INCOMPLETE RASTER ') (A) ,.
116                      GO TO NXTRST ,.
117                      END ,.
118              END,.
             /* THIS IS THE RING INTEGRATION ROUTINE */
119                  SUM = 0  ,.
120                  SIGMA = 0 ,.
121                  ITFLG = 10 ,.
122                  DO N = 1 TO 10 ,.
123                    LIM = N - 1 ,.
124                    JX1 = IX - LIM ,.
125                    JX2 = IX + LIM ,.
126                    JY1 = IY - LIM ,.
127                    JY2 = IY + LIM ,.
```

/* AS&F OSO-9 PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                    JDY2 = 2* LIM ,.
                    DEL = 0. ,.
                    NBAD = 0 ,.
                    RING = 0 ,.
                    BACK = 0 ,.
                    IF N = 1 THEN NBOX = 1 ,.
                             ELSE NBOX = 8*LIM ,.
                    DO JX = JX1 TO JX2 ,.
                      IF JX = JX1 OR JX = JX2 THEN JDY = 1 ,.
                                                   ELSE JDY = JDY2 ,.
                      IF JX LE 0 OR JX GT 40  THEN GO TO BADX ,.
                      JT = MOD(JX,2) ,.
                      DO JY = JY1 TO JY2 BY JDY ,.
                        IF JY LE 0 OR JY GT 48 THEN GO TO BADY ,.
                        IF JT = 1 THEN NDX=48*(JX - 1)+JY ,.
                                  ELSE NDX = 48*JX - JY +1 ,.
                        IF NDX GT ISIZE THEN GO TO BADY ,.
                        IF IRASRY(NDX) AND '00000011'B THEN GO TO BADY  ,.
                        CALL PTWRDC(IRASRY,NDX,NUM,NBAR) ,.
                        RING = RING + NBAR ,.
                        BACK = BACK + BAKRAY(NDX) ,.
                        GO TO NDYLP ,.
             BADY..     NBAD = NBAD+ 1 ,.
             NDYLP..    END ,.
                      GO TO NDXLP ,.
             BADX..   DO JY = JY1 TO JY2 BY JDY ,.
                        NBAD = NBAD + 1 ,.
                        END ,.
             NDXLP..  END ,.
                    CONTRIB = RING - BACK ,.
                    IF N GE 3 AND CONTRIB LE SQRT(BACK) THEN GO TO ENDIT ,.
                    BOX = NBOX ,.
                    BAD = NBAD ,.
                    IF BOX - BAD LE 0.9 THEN GO TO ENDIT ,.
                    GEOM = BOX/(BOX -BAD) ,.
                    DEL = GEOM * SQRT(RING + BACK) ,.
                    SUM = SUM + CONTRIB * GEOM  ,.
                    SIGMA = SQRT(SIGMA*SIGMA + DEL*DEL) ,.
                    GO TO NONLP ,.
             ENDIT.. ITFLG = N-1 ,.
                    GO TO COMPUT ,.
             NONLP..END ,.
             COMPUT..KR = ITFLG ,.
                  IF KR = 0  THEN KR = 1,.
                  FSUM = SUM*CALCO/RADCO(IAWL,KR) ,.
                  ERR = SIGMA*CALCO/RADCO(IAWL,KR) ,.
                  CORTYM = UTIME + IX*5.12/48/1440,.
             SAMPI..IF JFWEEL NE 2 AND JFWEEL NE 1 THEN GO TO COMPT1,.
             IF IAWL NE 1 THEN GO TO COMPT1,.
                  IB = IB +1,.
                  IF IB = 1 THEN DO,.
```

```
/* AS&E USO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

 179                        MONAM1 = MONAME,.
 180                        IDAT1 = IDATE1,.
 181                        DAYNUM = IDAT1,.
 182                       ZILCH = ' ',.
 183                        CHAR = MONAM1 CAT ZILCH CAT DAYNUM,.
 184                   NCHAR = 7,.
 185                   CALL SYMBOL(0.0E0,-0.4E0,0.07E0,CHAR,0.0E0,NCHAR),.
 186                   IUBGN = CORTYM,.
 187                        END,.
 188                   IOMEGA = 3,.
 189                   IF IAWL = 2 THEN IOMEGA = 4,.
 190              IF JFWEEL = 1 THEN IOMEGA=0,.
 191                   IF FSUM LE 0.1E03 THEN DO,.
 192              XCORD = 5*(CORTYM - IUBGN)/6;
 193               CALL PLOT (XCORD,0.0E0,118),.    CALL PLOT (XCORD,0.20E0,108),.
 195                GO TO COMPT1,.     END,.
 197                   FSUMO = LOG10(FSUM),.
 198                   IMP = 0,.
 199                   IF FSUMO GT 5.0 THEN DO,.
 200                       FSUMO = FSUMO - 3,.
 201                       IMP = 1,.
 202                       END,.
 203                   YCOOR = (FSUMO-2)*10/3,.
 204              XCOOR = 5*(CORTYM - IUBGN)/6;
 205                   ICODE = -1,.
 206                   CALL SYMBOL(XCOOR,YCOOR,0.07E0,IOMEGA,0.0E0,ICODE),.
 207                   IF IMP = 1 THEN DO,.
 208                   VN = YCOOR + 0.2,.
 209                       LINDEX = 62,.
 210                       CALL SYMBOL(XCOOR,VN,0.07E0,LINDEX,0.0E0,ICODE),.
 211                       END,.
 212                   IF ISUM GE 4000 THEN DO,.
 213                       NVN = 29,.
 214                       YCOOR = YCOOR - 0.10,.
 215                       CALL SYMBOL(XCOOR,YCOOR,0.07E0,NVN,0.0E0,ICODE),.
 216                       END,.
                  /* NOW PRINT THE RESULT */
 217               COMPT1..PUT EDIT('INTEGRAL OVER ',KR,' RINGS = ',SUM,'SIGMA = ',SIGMA)
                              (SKIP    ,COLUMN(10),A,F(3),A,F(8,1),X(3),A,F(7,1)) ,.
 218                   PUT EDIT ('CORRECTED VALUES---INTEGRAL = ',FSUM,'BRAC = ',ERR)
                              (COLUMN(10),A,F(8,1),X(2),A,F(7,1)) ,.
 219                   GO TO NXTRST ,.
 220              SWITCH..CALL CRDS ,.
 221                   CALL PRINFO ,.
 222                   GO TO BGTM ,.
 223              ENDBG..PUT EDIT ('END OF FILE ON BACKGROUND TAPE') (PAGE, A) ,.
 224                   GO TO FINISH ,.
 225              RNGBG..PUT EDIT ('BG TAPE READS START = ', UTSTART,'CARDS END AT',
                          USWCH) (PAGE, A, F(10,5), A, F(10,5)),.
 226                   GO TO FINISH ,.
 227              BADBG..PUT EDIT ('BAD BG AT' ,UTSTRT) (SKIP(3),A,X(2),F(10,5)),.
```

/* AS&E OSO-D PROGRAMS//SUM COUNTS IN SUBRASTERS--SUBSUM */

```
                  GO TO NXTBG,.
             NORST..PUT EDIT('END OF FILE ON TELEMETRY TAPE') (PAGE,A) ,.
             FINISH..PUT EDIT ('PROGRAM TERMINATED INTERNALLY') (SKIP(3),A) ,.
             AXLEN = 25.0E0;
                BGNN = IUBGN * 1.0E00    ,.
             CALL AXIS(0.0E0,0.0E0,'    ',-11B,AXLEN,0.0E0,BGNN,1.2E0);
             DO JKL = 1 TO 30;
             FUDGE = JKL*0.20E0;
             CALL PLOT(FUDGE,10.0E0,11B);
             CALL PLOT(FUDGE,9.80E0,10B);
             END;
             DO JKL = 1 TO 30;
             FUDGE = JKL*0.20E0;
             CALL PLOT(FUDGE,0.0E0,11B);
             CALL PLOT(FUDGE,-0.2E0,10B);
             END;
                  IPEN = 999,.
                  CALL PLOT(0.0E0,0.0E0,IPEN),.
                  PUT EDIT ('CALCOMP TAPE MADE') (SKIP(3),A),.
                  CALL RUNTL ,.
                  CLOSE FILE (INTAPE) ,.
                  CALL RUNFIL (INTAPE) ,.
                  END ,.
```

/* AS&E OSO-D PROGRAMS// PLAGE INTEGRALS--PLGINT */

```
                 /* AS&E OSO-D PROGRAMS// PLAGE INTEGRALS--PLGINT */
  1              PLGINT..PROCEDURE OPTIONS (MAIN) ,.
  2              DECLARE CRDRDR FILE STREAM INPUT
                      ENVIRONMENT (F(80) MEDIUM(SYSIPT,1442)),.
  3              DECLARE ICL(10),IRO(10) ,.
  4              DECLARE RECID POINTER ,.
  5              DECLARE 1 INRECD BASED(RECID) ALIGNED ,
                           2 (EPS, UTSTRT, UTSTOP, XNBARCAL, DELCAL, XN40CAL, DEL40CAL,
                              XN40ONE, DEL40ONE, BAKRAY(1920) FIXED DECIMAL (3,1)) ,.
  6              DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                               ENVIRONMENT (V(3884) MEDIUM(SYS009,2400) NOLABFL LEAVE),.
  7              DECLARE 1 RASTER EXTERNAL ALIGNED, 2 (UTIME, UTIM05) FLOAT BINARY(53),
                           2 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                          JFWEEL, JAWEEL) FIXED BINARY(31), 2 (IRASRY(1920), ISC05R(10),
                          ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
  8              DECLARE (DATE, SDATE, YRDATE) FLOAT BINARY(53) ,.
  9              DECLARE NBAR FLOAT ,.
 10              DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20), MONAME CHARACTER(4),
                         SGN CHARACTER(1) ,.
 11              DECLARE RADCO(2,10) ,.
 12                   ON ENDFILE (INTAPE) GO TO ENDBG,.
 13              ON ENDFILE (CRDRDR) GO TO ENDCD,.
 14              ON TRANSMIT (INTAPE) GO TO BADBG,.
 15                   CALL NTRAST,.
 16                   UTO = 39490,.
 17                   CALL REWFIL (INTAPE),.
 18                   OPEN FILE (INTAPE),.
 19                   UTIME = -100.E40,.
 20                   DO IN = 1 TO 2 ,.
 21                   GET FILE (CRDRDR) EDIT (L,(RADCO(L,M) DO M = 1 TO 10))
                        (COLUMN(1),F(2),10(X(2),F(4,3))),.
 22                     END,.
 23                   CALL CRDS ,.
 24                 CALL PRINPUT,.
 25                   GO TO FSTBG,.
 26              NXTBG..READ FILE (INTAPE) SET (RECID) ,.
 27              FSTBG..READ FILE (INTAPE) SET (RECID) ,.
 28              BGTM.. IF UTSTOP LT UBGN THEN GO TO NXTBG,.
 29                   UTOT = UTSTOP - UTSTRT ,.
 30                   IF UTOT LT 0.334 THEN GO TO NXTBG,.
 31                       CALCO=(1.340*EXP((300.0-UTSTRT)/1400.0))/XNBARCAL,.
                 /* PRINT OUT BG RASTER HEAD */
 32                   PUT EDIT ('NEW BACKGROUND RASTER FROM ',UTSTRT,' TO ',UTSTOP,
                      'NBARCAL = ',XNBARCAL,' CALCO = ',CALCO) (SKIP(3),A,F(10,5),A,
                      F(10,5),SKIP,COLUMN(10),A,F(5,3),X(5),A,F(5,3)),.
 33                   GO TO TESTIM ,.
 34              NXTRST..CALL NXRAST ,.
 35                   IF IEOF NE 0 THEN GO TO NDRST ,.
 36              TESTIM..IF UTIME LT UBGN THEN GO TO NXTRST ,.
 37                   IAWL = JAWEEL ,.
 38                   IF IAWL = 3 THEN IAWL =2 ,.
```

```
/* AS&E OSO-D PROGRAMS// PLAGE INTEGRALS--PLGINT */

 39                 IF IAWL = 4 THEN IAWL =1 ,.
 40                 IF IAWL = 5 OR JFWEEL =5 THEN GO TO NXTRST,.
 41                 CALL PUTRAS ,.
 42                 DO  JPL = 1 TO NPL ,.
 43                     IX = ICL(JPL) ,.
 44                     IY = IRO(JPL) ,.
 45                     CALL RINGINT ,.
 46                     END ,.
 47                 CALL CRDS ,.
 48                 CALL BRINPUT ,.
 49                 GO TO BGTM ,.
 50            ENDBG..PUT EDIT ('END OF FILE ON BACKGROUND TAPE') (PAGE, A) ,.
 51                 GO TO FINISH ,.
 52            NDRST..PUT EDIT('END OF FILE ON TELEMETRY TAPE') (PAGE,A) ,.
 53                 GO TO FINISH ,.
 54            BADBG..PUT EDIT ('FOUL UP ON BG TAPE') (SKIP(2),A) ,.
 55                 GO TO BGTM ,.
 56            ENDCD..PUT EDIT ('END OF FILE ON CARD READER') (PAGE,A) ,.
 57                 GO TO FINISH ,.
 58            FINISH..PUT EDIT ('PROGRAM TERMINATED INTERNALLY') (SKIP(3),A) ,.
 59                 CALL RUNTL ,.
 60                 CLOSE FILE (INTAPE) ,.
 61                 CALL RUNFIL (INTAPE) ,.
 62            RINGINT..PROCEDURE,.
               /* THIS IS THE RING INTEGRATICN ROUTINE */
 63                 SUM = 0  ,.
 64                 SIGMA = 0 ,.
 65                 ITFLG = 10 ,.
 66                 DO N = 1 TO 10 ,.
 67                   LIM = N - 1 ,.
 68                   JX1 = IX - LIM ,.
 69                   JX2 = IX + LIM ,.
 70                   JY1 = IY - LIM ,.
 71                   JY2 = IY + LIM ,.
 72                   JDY2 = 2* LIM ,.
 73                   DEL = 0. ,.
 74                   NBAD = 0 ,.
 75                   RING = 0 ,.
 76                   BACK = 0 ,.
 77                   IF N = 1 THEN NBOX = 1 ,.
 78                            ELSE NBOX = 8*LIM ,.
 79                   DO JX = JX1 TO JX2 ,.
 80                     IF JX = JX1 OR JX = JX2 THEN JDY = 1 ,.
 81                                                  ELSE JDY = JDY2 ,.
 82                     IF JX LE 0 OR JX GT 40  THEN GO TO BADX ,.
 83                     JT = MOD(JX,2) ,.
 84                     DO JY = JY1 TO JY2 BY JDY ,.
 85                       IF JY LE 0 OR JY GT 48 THEN GO TO BADY ,.
 86                       IF JT = 1 THEN NDX=48*(JX - 1)+JY ,.
 87                                 ELSE NDX = 48*JX - JY +1 ,.
 88                       IF NDX GT ISIZE THEN GO TO BADY ,.
```

```
/* AS&E OSO-D PROGRAMS// PLAGE INTEGRALS--PLGINT */
  89                          IF IRASRY(NDX) AND '00000011'B THEN GO TO BADY  ,.
  90                          CALL PTWRDC(IRASRY,NDX,NUM,NBAR) ,.
  91                          RING = RING + NBAR ,.
  92                          BACK = BACK + BAKRAY(NDX) ,.
  93                          GO TO NDYLP ,.
  94               BADY..     NBAD = NBAD+ 1 ,.
  95               NDYLP..    END ,.
  96                        GO TO NDXLP ,.
  97               BADX..   DO JY = JY1 TO JY2 BY JDY ,.
  98                          NBAD = NBAD + 1 ,.
  99                          END ,.
 100               NDXLP..  END ,.
 101                      CONTRIB = RING - BACK ,.
 102                      IF N GE 3 AND CONTRIB LE SQRT(BACK) THEN GO TO ENDIT ,.
 103                      BOX = NBOX ,.
 104                      BAD = NBAD ,.
 105                      IF BOX - BAD LE 0.9 THEN GO TO ENDIT ,.
 106                      GEOM = BOX/(BOX -BAD) ,.
 107                      DEL = GEOM * SQRT(RING + BACK) ,.
 108                      SUM = SUM + CONTRIB * GEOM   ,.
 109                      SIGMA = SQRT(SIGMA*SIGMA + DEL*DEL) ,.
 110                      GO TO NDNLP ,.
 111               ENDIT.. ITFLG = N-1 ,.
 112                      GO TO COMPUT ,.
 113               NDNLP..END ,.
 114               COMPUT..KR = ITFLG ,.
 115                    FSUM = SUM*CALCO/RADCO(IAWL,KR) ,.
 116                    ERR = SIGMA*CALCO/RADCO(IAWL,KR) ,.
                   /* NOW PRINT THE RESULT */
 117                    PUT EDIT ('RING INTEGRATION OF REGION AT (',IX, ',' ,IY, ')')
                           (SKIP(3),A,F(3),A,F(3),A) ,.
 118                    PUT EDIT ('INTEGRAL OVER ',KR,' RINGS = ',SUM,'SIGMA = ',SIGMA)
                               (SKIP   ,COLUMN(10),A,F(3),A,F(8,1),X(3),A,F(7,1)) ,.
 119                    PUT EDIT ('CORRECTED VALUES---INTEGRAL = ',FSUM,'BRAC = ',ERR)
                               (COLUMN(10),A,F(8,1),X(2),A,F(7,1)) ,.
 120                    END RINGINT ,.
 121               CRDS..PROCEDURE ,.
 122                    GET FILE (CRDRDR) EDIT (DAY,HR,XMN,N,(ICL(M),IRD(M) DO M=1 TO N))
                           (SKIP,F(3),2(X(1),F(2)),F(2),9(X(2),F(2),X(1),F(2))) ,.
 123                    UBGN = DAY + HR/24.00+(XMN-1.0)/1440.0,.
 124                    NPL = N ,.
 125                    END CRDS ,.
 126               PUTRAS..PROCEDURE,.
                   /* PRINTOUT RASTER HEADING HERE */
 127                    SDATE = UTIME + UTO,.
 128                    CALL SDAY (SDATE,IYEAR,YRDATE,MONTH,DATE,MONAME),.
 129                    IDATE1=DATE,.
 130                    IYRDATE =YRDATE,.
 131                    HRS = 24.* (DATE - IDATE1),.
 132                    CALL DEGDMS (HRS,ISGN,IHR,MIN,SECS) ,.
 133                    CALL FLTLUK (JFWEEL,FNAME,QLAM1,QLAM2,FNX,FEX),.
```

/* AS&E OSO-D PROGRAMS// PLAGE INTEGRALS--PLGINT */

```
 134                    CALL APTLUK (JAWEEL, ANAME) ,.
 135                    PUT EDIT ('RASTER SCAN STARTING AT', MONAME, IDATE1, ',', IYEAR,
                             '   UT TIME', IHR, MIN, SECS, 'DAY NOTATION', UTIME)
                             (SKIP(3),A,X(2),A,F(3,0),A,F(5,0),A,2 F(3,0),F(6,2),X(5),A,
                             F(10,5)) ,.
 136                    PUT EDIT (FNAME,ANAME) (SKIP, A, X(10), A) ,.
 137                    END PUTRAS,.
 138               PRINPUT..PROCEDURE,.
 139                         PUT EDIT ('INTEGRATION OF ',NPL,' PLAGES ON DAY ',DAY,HR,
                             ' HRS',XMN,' MINS  UBGN = ',UBGN) (PAGE,A,F(2),A,F(3),X(2),
                             F(3),A,X(2),F(3),A,F(10,5)),.
 140                         PUT EDIT ('ICL','IRO') (SKIP(3),COLUMN(9),A,COLUMN(19),A),.
 141                         DO M = 1 TO NPL,.
 142                            PUT EDIT (ICL(M),IRO(M)) (SKIP,COLUMN(9),F(3),COLUMN(19),
                                  F(3)),.
 143                            END,.
 144                         END PRINPUT,.
 145                    END ,.
```

/* AS&E OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS */

```
                  /* AS&E OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS   */
  1               ARST.. PROCEDURE OPTIONS (MAIN),.
  2               DECLARE ILINEPIC PICTURE '99', ILINEOUT CHARACTER(2)
                          DEFINED ILINEPIC, COLID CHARACTER(80),.
  3               DECLARE RECID POINTER,.
  4               DECLARE 1 INRECD BASED(RECID) ALIGNED, 2(EPS, UTSTRT, UTSTOP, XNBARCAL,
                          DELCAL, XN40CAL, DEL40CAL, XN40ONE, DEL40ONE,
                          BAKRAY(1920) FIXED DECIMAL (3,1)),.
  5               DECLARE RECIDO POINTER,.
  6               DECLARE 01 OUTRECD BASED (RECIDO) ALIGNED, 2(UTAVLO, UTAVHI, ITOTCTAV,
                          JAWEELAV, JFWEELAV, INCOMPLETECTAV, LARGMISSINGCTAV,
                          LARGQUESTCTAV, IDECLAREDBADCTAV, NRASTAV,
                          IFRSTINDAYAV, AVRAY(1920)),.
  7               DECLARE OUTAPE FILE RECORD SEQUENTIAL OUTPUT ENVIRONMENT (V(7732)
                          MEDIUM(SYS008, 2400) NOLABEL LEAVE),.
  8               DECLARE MESSAGE CHARACTER(60), INDICAV BIT(1),.
  9               DECLARE DUMMY CHARACTER(1),.
 10               DECLARE SYSIN FILE STREAM INPUT ENVIRONMENT (F(80)
                          MEDIUM(SYSIPT, 1442)),.
 11               DECLARE INTAPE FILE RECORD SEQUENTIAL BUFFERED INPUT
                          ENVIRONMENT (V(3884) MEDIUM(SYS009,2400) NOLABEL LEAVE),.
 12               DECLARE 01 RASTER EXTERNAL ALIGNED, 2(UTIME, UTIMO5) FLOAT BINARY(53),
                          02 (ISIZE, ISUBSZ, IBADCT, ISKPED, IMISS, IENDN, IEOF,
                          JFWEEL, JAWEEL) FIXED BINARY(31), 02 (IRASRY(1920),
                          ISC05R(10), ISC07R(10), ISC27R(10), ISC44R(10)) BIT(16),.
 13               DECLARE UTO FLOAT BINARY(53),.
 14               DECLARE NBAR FLOAT,.
 15               DECLARE KEYUSED PICTURE '(8)9', NRAST(3,2), IRECRY(3,2),.
 16               DECLARE 01 TEMPRECD, 02 CORRAY(320), 02 NRAY(320),.
 17               DECLARE FIRSTRASTERUT(3,2), RASTERUTLAST(3,2),.
 18               DECLARE TOTFIL FILE RECORD DIRECT KEYED UPDATE ENVIRONMENT (F(2560)
                          MEDIUM (SYS000, 2311) REGIONAL(1)),.
 19               DECLARE INCOMPLETECT(3,2), LARGMISSINGCT(3,2), LARGQUESTCT(3,2),
                          IDECLAREDBADCT(3,2), ITOTCT(3,2), IFRSTINDAY(3,2),.
 20               DECLARE DTMAX(2), IRASTRWANTED(2),.
 21               ON ENDFILE (INTAPE) GO TO ENDBACKGROUND,.
 22               ON ENDFILE (SYSIN ) GO TO ENDSYSIN,.
 23               COLID = '01      05       10       15       20       25       30
                      35       40',.
 24                    CALL NTRAST,.
 25                    UTO = 39490,.
 26                    CALL REWFIL (INTAPE),.
 27                    CALL REWFIL (OUTAPE),.
 28                    OPEN FILE (TOTFIL), FILE (INTAPE), FILE (OUTAPE),.
 29                    NRAST = 0,.
 30                    INDICAV = '0'B,.
 31                    ITOTCT = 0,.
 32                    IFRSTINDAY = 0,.
 33                    IENDN = 0,.
 34                    INCOMPLETECT = 0,.
 35                    LARGMISSINGCT = 0,.
```

```
/* ASEE OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS    */

   36                  LARGQUESTCT = 0,.
   37                  IDECLAREDBADCT = 0,.
   38                  CORRAY = 0.,.
   39                  NRAY = 0,.
   40                  IRECD = 0,.
   41                  DO I = 1 TO 3,.
   42                  DO J = 1 TO 2,.
   43                  IRECRY(I, J) = IRECD,.
   44                  DO JJ = 1 TO 6,.
   45                  KEYUSED = IRECD,.
   46                  WRITE FILE (TOTFIL) FROM (TEMPRECD) KEYFROM (KEYUSED),.
   47                  IRECD = IRECD + 1,. END,.
   49                  END,. END,.
   51                  GET FILE(SYSIN) EDIT(UTBEGN, UTEND, DTMAX, IRASTRWANTED,DUMMY)
                          (2F(15,5), 4F(10,0), A(10)),.
   52                  IF DTMAX(1) LT 0. OR DTMAX(2) LT 0. OR IRASTRWANTED(1) LE 0
                          OR IRASTRWANTED(2) LE 0 OR UTBEGN GE UTEND THEN DO,.
   53                     PUT EDIT ('INPUT ERROR') (SKIP, A),. GO TO WRAPUP,. END,.
   56                  FLARUTHI = -1.E+60,.
   57                  FLARUTLO = -1.E+60,.
   58                  UTIME = -100.E40,.
   59                  GO TO FIRSTBACKGROUND,.
   60            NEXTBACKGROUND.. READ FILE (INTAPE) SET (RECID),.
   61            FIRSTBACKGROUND.. READ FILE (INTAPE) SET (RECID),.
   62                  IF UTSTOP LT UTBEGN THEN GO TO NEXTBACKGROUND,.
   63                  IF UTSTOP - UTSTRT LT 0.3333 THEN GO TO NEXTBACKGROUND,.
   64                  IF UTSTRT GT UTEND + 0.333333 THEN GO TO BACKGROUNDTIMEHI,.
   65                  GO TO TESTRASTIME,.
   66            NEXTRASTER.. IENDNB4 = IENDN,.
   67                  CALL NXRAST,.
   68                  IF IEOF NE 0 THEN GO TO ENDFILERASTERS,.
   69            TESTRASTIME.. IF UTIME LT UTSTRT THEN GO TO NEXTRASTER,.
   70                  IF UTIME LT UTBEGN THEN GO TO NEXTRASTER,.
   71                  IF UTIME GT UTEND THEN GO TO MAXTIMEXCEEDED,.
   72                  DO I = 1 TO 3,.
   73                  DO J = 1 TO 2,.
   74                  IF NRAST (I, J) NE 0 THEN IF UTIME - FIRSTRASTERUT (I, J)
                          GT DTMAX (J) THEN CALL PRINTRASTER (I, J),.
   75                  END,. END,.
   77                  IF UTIME GT UTSTOP THEN GO TO NEXTBACKGROUND,.
   78                  IF JFWEEL = 3 OR JFWEEL = 5 OR JAWEEL=5 THEN GO TO NEXTRASTER,.
   79                  IF IENDN = 1 THEN ISIZE = ISIZE - 80,.
   80                  IF JFWEEL = 4 THEN JFWEEL = 3,.
   81                  IF JAWEEL = 3 THEN JAWEEL=2,.
   82                  IF JAWEEL = 4 THEN JAWEEL = 1,.
   83            TESTFLARES.. IF UTIME LT FLARUTLO THEN GO TO NOFLARES,.
   84                  IF UTIME GT FLARUTHI THEN DO,. GET FILE (SYSIN) EDIT (FLARUTLO,
   86                     FLARUTHI, DUMMY) (2F(15,5), A(50)),.GO TO TESTFLARES,.END,.
   88                  IDECLAREDBADCT(JFWEEL,JAWEEL)=IDECLAREDBADCT(JFWEEL,JAWEEL)+1,.
   89                  GO TO NEXTRASTER,.
   90            NOFLARES.. ITOTCT(JFWEEL,JAWEEL) = ITOTCT (JFWEEL,JAWEEL) + 1,.
```

```
/* AS&F OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS   */
 91                       IF ISIZE LT 1920 THEN DO,. INCOMPLETECT(JFWEEL, JAWEEL) =
                              INCOMPLETECT (JFWEEL, JAWEEL) + 1,.
 93                           GO TO NEXTRASTER,. END,.
 95                       IF IMISS GT 100 THEN DO,. LARGMISSINGCT (JFWEEL, JAWEEL) =
 97                           LARGMISSINGCT (JFWEEL, JAWEEL) + 1,.  GO TO NEXTRASTER,.
 98                           END,.
 99                       IF IBADCT GT 100 THEN DO,. LARGQUESTCT(JFWEEL,JAWEEL) =
101                           LARGQUESTCT(JFWEEL,JAWEEL)+1,. GO TO NEXTRASTER,. END,.
                 /* THIS RASTER IS OK, SO ADD IT TO TOTALS  */
103                       IF IENDNB4=1 THEN IFRSTINDAY(JFWEEL,JAWEEL) = IFRSTINDAY
                              (JFWEEL, JAWEEL) + 1,.
104                       IF NRAST (JFWEEL, JAWEEL) = 0 THEN FIRSTRASTERUT(JFWEEL,
                              JAWEEL) = UTIME,.
105                       RASTERUTLAST(JFWEEL, JAWEEL) = UTIME,.
106                       IRECD = IRECRY (JFWEEL, JAWEEL),.
107                       NRAST (JFWEEL, JAWEEL) = NRAST (JFWEEL, JAWEEL) + 1,.
108                       INDEX1 = 0,.
109                       DO M = 1 TO 6,.
110                       KEYUSED = IRECD,.
111                       READ FILE (TOTFIL) INTO (TEMPRECD) KEY (KEYUSED),.
112                       DO J = 1 TO 320,.
113                       INDEX1 = INDEX1 + 1,.
114                       IF IENDNB4 = 1 AND INDEX1 LE 240 THEN GO TO SKIPWRD,.
115                       IF IRASRY(INDEX1) AND '00000011'B THEN GO TO SKIPWRD,.
116                       CALL PTWRDC (IRASRY, INDEX1, N, NBAR),.
117                       CORRAY(J) = CORRAY(J) + NBAR,.
118                       NRAY(J) = NRAY(J) + 1,.
119              SKIPWRD.. END,.
120                       REWRITE FILE (TOTFIL) FROM (TEMPRECD) KEY (KEYUSED),.
121                       IRECD = IRECD + 1,.
122                       END,.
123                       IF NRAST(JFWEEL,JAWEEL) GE IRASTRWANTED(JAWEEL) THEN CALL
                              PRINTRASTER (JFWEEL, JAWEEL),.
124                       GO TO NEXTRASTER,.
125              ENDBACKGROUND.. PUT EDIT ('END OF FILE ON BACKGROUND RASTER TAPE')
                              (SKIP(2), A),.
126                       ITOTCT = 0,.
127                       GO TO WRAPUP,.
128              BACKGROUNDTIMEHI.. PUT EDIT ('MAXIMUM REQUESTED TIME EXCEEDED ON BACKGR
                 OUND RASTER TAPE') (SKIP(2), A),.
129                       GO TO WRAPUP,.
130              ENDFILERASTERS.. PUT EDIT ('END OF FILE ON TELEMETRY TAPE') (SKIP(2),
                              A),.
131                       GO TO WRAPUP,.
132              MAXTIMEXCEEDED.. PUT EDIT ('MAXIMUM REQUESTED TIME EXCEEDED ON TELEMETR
                 Y TAPE') (SKIP(2), A),.
133              WRAPUP.. CALL RUNTL,.
134                       CLOSE FILE (INTAPE),.
135                       CALL RUNFIL (INTAPE),.
136                       DO JFWEEL = 1 TO 3,.
137                       DO JAWEEL = 1 TO 2,.
```

```
/* AS&E OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS    */

  138                  CALL PRINTRASTER (JFWEEL, JAWEEL),.
  139                  END,. END,.
  141                  CLOSE FILE (TOTFIL), FILE (OUTAPE),.
  142                  CALL RUNFIL (OUTAPE),.
  143                  DISPLAY ('LABEL OUTPUT TAPE ON SYS008 AS FOLLOWS --'),.
  144                  PUT STRING (MESSAGE) EDIT ('"AVERAGE CORRECTED RASTERS FROM',
                           UTAVLOLO, ' TO ', UTAVHIHI, '"') (A, F(7,1), A, F(7,1), A
                           ),.
  145                  DISPLAY (MESSAGE),.
  146                  STOP,.
  147          ENDSYSIN.. FLARUTLO = 1.E+60,.
  148                  FLARUTHI = 1.E+60,.
  149                  GO TO NOFLARES,.
  150          ASIN.. PROCEDURE (X),.
  151                  RETURN (ATAN (X / SQRT (1. - X * X))),.
  152          END,.
               /* THIS PROCEDURE PRINTS OUT AN AVERAGE RASTER
                 AND ASSOCIATED STATISTICS  */
  153          PRINTRASTER.. PROCEDURE (JFWEEL, JAWEEL),.
  154          DECLARE BIGRAY(1920) CHARACTER(2),.
  155          DECLARE FNAME CHARACTER(24), ANAME CHARACTER(20),.
  156          DECLARE MONAM1 CHARACTER(4), MONAM2 CHARACTER(4), SGN CHARACTER(1),.
  157          DECLARE KAY(40) CHARACTER(2), PIC PICTURE '9', IHR1, MIN1, SECS1,.
  158          DECLARE IYR1, (YRDATE1, YRDATE2, DATEA) FLOAT BINARY(53), FKNX, FKEX,.
  159          DECLARE QLAM1, QLAM2, IHR2, MIN2, SECS2, FN, FE, QLOG, QLOGTR,.
  160          DECLARE QLOGER, ITEMP, TEMP, M, J, INDEX1, IDATE1, IDATE2, IRECD,IPIC,.
  161          DECLARE IYR2,.
  162                  IF ITOTCT (JFWEEL, JAWEEL) LE 0 THEN RETURN,.
  163                  CALL SDAY (FIRSTRASTERUT(JFWEEL, JAWEEL) + UT0, IYR1, YRDATE1,
                           MONTH, DATEA, MONAM1),.
  164                  IDATE1 = DATEA,.
  165                  CALL DEGDMS (24.*(DATEA-IDATE1), ISGN, IHR1, MIN1, SECS1),.
  166                  CALL SDAY (RASTERUTLAST(JFWEEL, JAWEEL) + UT0, IYR2, YRDATE2,
                           MONTH, DATEA, MONAM2),.
  167                  IDATE2 = DATEA,.
  168                  CALL DEGDMS (24.*(DATEA-IDATE2), ISGN, IHR2, MIN2, SECS2),.
  169                  IF JFWEEL = 3 THEN M = 4,. ELSE M = JFWEEL,.
  171                  CALL FLTLUK (M, FNAME, QLAM1, QLAM2, FKNX, FKEX),.
  172                  CALL APTLUK (JAWEEL, ANAME),.
  173                  FN = FKNX / EPS,.
  174                  FE = FKEX / EPS,.
  175                  CALL NEWPAGE,.
  176                  PUT EDIT (' ') (SKIP(2), A),.
  177                  PUT EDIT (ITOTCT(JFWEEL, JAWEEL), 'RASTERS READ',
                           INCOMPLETECT(JFWEEL, JAWEEL), 'WERE INCOMPLETE',
                           LARGMISSINGCT(JFWEEL, JAWEEL), 'HAD MORE THAN 100 INTERSPER
               SED MISSING WORDS',
                           LARGQUESTCT(JFWEEL, JAWEEL), 'HAD MORE THAN 100 QUESTIONABL
               E WORDS',
                           IDECLAREDBADCT(JFWEEL, JAWEEL), 'RASTERS WERE IN TIME INTER
               VALS DECLARED AS BAD',
```

```
/* AS&E OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS    */

                                  NRAST(JFWEEL, JAWEEL), 'RASTERS WERE USED',
                                  IFRSTINDAY(JFWEEL, JAWEEL), 'RASTERS WERE 1ST SINCE SUNRISE
                 ')
                                  (SKIP, F(6,0), X(1), A),.
  178                        LOCATE OUTRECD FILE (OUTAPE) SET (RECIDO),.
  179                        UTAVLO = FIRSTRASTERUT(JFWEEL, JAWEEL),.
  180                        IF NOT INDICAV THEN DO,. INDICAV='1'B,. UTAVLOLO = UTAVLO,.
  183                            END,.
  184                        UTAVHI = RASTERUTLAST (JFWEEL, JAWEEL),.
  185                        UTAVHIHI = UTAVHI,.
  186                        ITOTCTAV = ITOTCT (JFWEEL, JAWEEL),.
  187                        JFWEELAV = M,.
  188                        JAWEELAV = JAWEEL,.
  189                        INCOMPLETECTAV = INCOMPLETECT(JFWEEL, JAWEEL),.
  190                        LARGMISSINGCTAV = LARGMISSINGCT (JFWEEL, JAWEEL),.
  191                        LARGQUESTCTAV = LARGQUESTCT (JFWEEL, JAWEEL),.
  192                        IDECLAREDBADCTAV = IDECLAREDBADCT (JFWEEL, JAWEEL),.
  193                        NRASTAV = NRAST (JFWEEL, JAWEEL),.
  194                        IFRSTINDAYAV = IFRSTINDAY (JFWEEL, JAWEEL),.
  195                        AVRAY = 0.,.
  196                        IRECD = IRECRY(JFWEEL, JAWEEL),.
  197                        INDEX1 = 0,.
  198                        DO M = 1 TO 6,.
  199                        KEYUSED = IRECD,.
  200                        READ FILE (TOTFIL) INTO (TEMPRECD) KEY (KEYUSED),.
  201                        DO J = 1 TO 320,.
  202                        INDEX1 = INDEX1 + 1,.
  203                        IF NRAY(J) LE 0 THEN DO,.BIGRAY(INDEX1)='++',.GO TO ENDJ,.END,.
  207                        AVRAY (INDEX1) = CORRAY(J) / NRAY(J) - BAKRAY(INDEX1),.
  208                        TEMP = AVRAY(INDEX1) + 1.0,.
  209                        IF TEMP LT 1.0 THEN DO,. BIGRAY(INDEX1) = '--',. GO TO ENDJ,.
  212                            END,.
  213                        QLOG = LOG2(TEMP),.
  214                        QLOGTR = TRUNC (QLOG),.
  215                        QLOGFR = (QLOG - QLOGTR) * 10.,.
  216                        ITEMP = QLOGFR + 0.5,.
  217                        IPIC = QLOGTR + 1.0,.
  218                        IF ITEMP GT 9 THEN DO,. ITEMP = 0,. IPIC = IPIC + 1,. END,.
  222                        PIC = ITEMP,.
  223                        SUBSTR (BIGRAY(INDEX1), 2, 1) = PIC,.
  224                        IF IPIC GT 35 THEN DO,. BIGRAY(INDEX1) = '**',. GO TO ENDJ,.
  227                            END,.
  228                        SUBSTR (BIGRAY(INDEX1), 1,1) = SUBSTR('0123456789ABCDEFGHIJKLMN
               OPQRSTUVWXYZ', IPIC, 1),.
  229              ENDJ.. END,.
  230                        CORRAY = 0.,.
  231                        NRAY = 0,.
  232                        REWRITE FILE (TOTFIL) FROM (TEMPRECD) KEY (KEYUSED),.
  233                        IRECD = IRECD + 1,.
  234                        END,.
  235                        INCOMPLETECT(JFWEEL, JAWEEL) = 0,.
```

```
/* AS&E OSO-D PROGRAMS // GET AVERAGE CORRECTED RASTERS    */

 236                    LARGMISSINGCT(JFWEEL,JAWEEL) = 0,.
 237                    ITOTCT (JFWEEL, JAWEEL) = 0,.
 238                    LARGQUESTCT(JFWEEL, JAWEEL) = 0,.
 239                    NRAST (JFWEEL, JAWEEL) = 0,.
 240                    IFRSTINDAY (JFWEEL, JAWEEL) = 0,.
 241                    IDECLAREDBADCT (JFWEEL, JAWEEL) = 0,.
 242                    CALL NEWPAGE,.
 243                    PUT EDIT ('LOG BASE 2 OF (AVERAGE CORRECTED COUNT RATE + 1)',
                           COLID) (SKIP(2), X(70), A, SKIP, X(4), A(80)),.
 244                    DO M = 1 TO 48,.
 245                    ILINE = 49 - M,.
 246                    ILINEOUT = ' ',.
 247                    IF ILINE=1 OR ILINE=48 OR (ILINE/5)*5=ILINE THEN ILINEPIC
                           = ILINE,.
 248                    KAY = ' ',.
 249                    DO J = 1 TO 39 BY 2,.
 250                    ISUBSCR = 48 * (J-1) + 49 - M,.
 251                    KAY(J) = BIGRAY(ISUBSCR),.
 252                    ISUBSCR = 48 * J + M,.
 253                    KAY(J+1) = BIGRAY(ISUBSCR),.
 254                    END,.
 255                    PUT EDIT (ILINEOUT, KAY, ILINEOUT) (SKIP, A(2), X(2), 40A(2),
                           X(2), A(2)),.
 256                    END,.
 257                    PUT EDIT (COLID) (SKIP, X(4), A(80)),.
 258                    RETURN,.
 259           NEWPAGE.. PROCEDURE,.
 260                    PUT EDIT ('AVERAGE CORRECTED RASTER FM ', IDATE1, MONAM1, IYR1,
                           IHR1, MIN1, SECS1, ' TO ', IDATE2, MONAM2, IYR2, IHR2,
                           MIN2, SECS2, '(', FIRSTRASTERUT(JFWEEL, JAWEEL), ' TO',
                           RASTERUTLAST(JFWEEL, JAWEEL), ')' )
                           (PAGE, A, F(3,0), X(1), A, 2F(5,0), F(3,0), F(5,1), A,
                           F(3,0), X(1), A, 2F(5,0), F(3,0), F(5,1), X(6), 2(A,F(9,3)
                           ), A),.
 261                    PUT EDIT (FNAME, 'LAMBDA 1 =', QLAM1, 'LAMBDA 2=', QLAM2,
                           'KN =', FN, 'KE =', FE) (SKIP, A, X(6), A, F(6,2), X(4),
                           A, F(6,2), X(5), A, F(8,2), X(5), A, F(8,2)),.
 262                    PUT EDIT (SUBSTR (ANAME, 4, 17), 'EPSILON =', EPS,
                           'N BAR CAL =', XNBARCAL, 'DELTA =', DELT)
                           (SKIP, X(3), A, X(10), A, F(7,2), X(10), A, F(8,2), X(9),A,
                           F(8,2)),.
 263                    RETURN,.
 264           END,.
 265           END,.
 266           END,.
```

/* AS&E OSO-D PROGRAMS // ASPECT-EPHEMERIS SUMMARY LISTING */

```
          /* AS&E OSO-D PROGRAMS // ASPECT-EPHEMERIS SUMMARY LISTING  */
   1      OSSM: PROCEDURE OPTIONS (MAIN);
   2      DECLARE (REWFIL, RUNFIL, FLCN93, DEGDMS) ENTRY;
   3      DECLARE UTIME FLOAT BINARY(53);
   4      DECLARE TAPEIN FILE INPUT RECORD BUFFERED SEQUENTIAL ENVIRONMENT
                  (U(3120) LEAVE MEDIUM(SYS007,2400) BUFFERS(2) NOLABEL);
   5      DECLARE 01 RECORDIN ALIGNED, 02 WORD_7090 (520) BIT(48);
   6      ON RECORD(TAPEIN);
   7              CALL REWFIL (TAPEIN);
   8              IPAGE = 0;
   9              LINES = 80;
  10      NEW_FILE: OPEN FILE (TAPEIN);
  11      ON ENDFILE(TAPEIN) GO TO END_RUN;
  12              DO I = 1 TO 4;
  13              READ FILE (TAPEIN) INTO (RECORDIN);
  14              END;
  15              READ FILE (TAPEIN) INTO (RECORDIN);
  16              IORBIT = FLCN93 (WORD_7090(54));
  17              SECS = FLCN93 (WORD_7090(56)) / 1000.;
  18              DAYNO = FLCN93 (WORD_7090(55));
  19              UTIME = DAYNO + 9490.;
  20              UTIME = UTIME + SECS / 86400.;
  21              UT_DAYSTART = FLCN93 (WORD_7090(63));
  22              UT_DAYEXIT = FLCN93 (WORD_7090(61));
  23              PITCH = FLCN93 (WORD_7090 (28));
  24              ROLL  = FLCN93 (WORD_7090 (29));
  25              SPINX = FLCN93 (WORD_7090(42));
  26              TEMP = FLCN93(WORD_7090(43));
  27              TEMP1 = FLCN93(WORD_7090(44));
  28              SPINY = TEMP * 0.9174532 + TEMP1 * 0.3978437;
  29              SPINZ = - TEMP * 0.3978437 + TEMP1 * 0.9174532;
  30              SUNX = FLCN93 (WORD_7090(16));
  31              TEMP = FLCN93(WORD_7090(17));
  32              TEMP1 = FLCN93(WORD_7090(18));
  33              SUNY = TEMP * 0.9174532 + TEMP1 * 0.3978437;
  34              SUNZ = - TEMP * 0.3978437 + TEMP1 * 0.9174532;
          /* AS&E OSO-4 SUBROUTINES // COMPUTE ANGLE BETWEEN SPIN AXIS AND THE
            SUN'S NORTH POLE    */
  35              SPD = SQRT (SPINX*SPINX + SPINY*SPINY + SPINZ*SPINZ),.
  36              SUND = SQRT (SUNX*SUNX + SUNY*SUNY + SUNZ*SUNZ),.
  37              SPINX = SPINX / SPD,.
  38              SPINY = SPINY / SPD,.
  39              SPINZ = SPINZ / SPD,.
  40              SUNX = SUNX / SUND,.
  41              SUNY = SUNY / SUND,.
  42              SUNZ = SUNZ / SUND,.
  43              FO = ASIN (SPINX * SUNX + SPINY * SUNY + SPINZ * SUNZ),.
  44              XL = ATAN (SUNY, SUNX),.
  45              R = 1.307899 + 0.6146465E-06 * (UTIME);
  46              BO = ASIN (SIN(XL-R) * 0.126199),.
  47              ALPHA = ACOS (0.992005 / COS(BO));
```

/* AS&E OSO-D PROGRAMS // ASPECT-EPHEMERIS SUMMARY LISTING */

```
48                      R_1 = R + 0.614665E-06;
49                      B_1 = ASIN (SIN(XL - R_1) * 0.126199);
50                      IF B_1 - B0 <= 0 THEN ALPHA = - ALPHA;
51                      RX = SIN(R) * 0.126199,.
52                      RY = - COS(R) * 0.126199,.
53                      COST2 = SPINX * RX + SPINY  * RY + 0.992005 * SPINZ,.
54                      V = ACOS (COST2),.
55                      S = 0.5 * (3.141593 + F0 + V - B0),.
56                      RP = ((SIN (0.5*(V-F0-B0)) * SIN(0.5*(3.141593+F0-V-B0))
                            * SIN (0.5*(F0+V+B0))) / SIN(S)),.
57                      RP = SQRT (ABS (RP)),.
58                      ARG4 = SIN (S-V),.
59                      PROD1 = SPINZ * SUNY - SPINY * SUNZ,.
60                      PROD2 = SPINX * SUNZ - SPINZ * SUNX,.
61                      PROD3 = SPINY * SUNX - SPINX * SUNY,.
62                      STEST = PROD1 * RX + PROD2 * RY + PROD3 * 0.992005,.
63                      ARG3 = RP * SIGN (STEST * ARG4),.
64                      DELTA = - 2.0 * ATAN (ARG3, ARG4) + 1.570796;
65                      HRS = SECS / 3600.;
66                      CALL DEGDMS (HRS, ISGN, IHR, IMIN, SEC);
67                      HRS = UT_DAYSTART / 3600000.;
68                      CALL DEGDMS (HRS, ISGN, IHR1, IMIN1, SEC1);
69                      HRS = UT_DAYEXIT / 3600000.;
70                      CALL DEGDMS (HRS, ISGN, IHR2, IMIN2, SEC2);
71                      ORBIT_END = FLCN93 (WORD_7090(58)) / 3600000.;
72                      CALL DEGDMS (ORBIT_END, ISGN, IHR3, IMIN3, SEC3);
73                      ALPHA = - ALPHA;
74                      PITCH = - PITCH;
75                      CALL NEW_PAGE_TEST;
76                      PUT EDIT (IORBIT, DAYNO, IHR, IMIN, SEC, IHR3, IMIN3, SEC3,
                            IHR1, IMIN1, SEC1, IHR2, IMIN2, SEC2, PITCH*57.2957795,
                            ROLL*57.2957795, ALPHA*57.2957795, DELTA*57.2957795)
                            (SKIP(1), 2 F(5), X(5), 3 F(3), X(3), 3 F(3), X(7), 3 F(3),
                            X(2), 3 F(3), 4 F(10,2));
77              ON ENDFILE(TAPEIN) GO TO END_OF_FILE;
78              NEXT_RECORD:  READ FILE (TAPEIN) INTO (RECORDIN);
79                      GO TO NEXT_RECORD;
80              END_OF_FILE:  CLOSE FILE (TAPEIN);
81                      GO TO NEW_FILE;
82              END_RUN:  CALL RUNFIL (TAPEIN);
83                      STOP;
84              NEW_PAGE_TEST: PROCEDURE;
85                      LINES = LINES + 1;
86                      IF LINES < 50 THEN RETURN;
87                      LINES = 0;
88                      IPAGE = IPAGE + 1;
89                      PUT EDIT ('OSO-D SUMMARY LISTING FROM ATTITUDE-EPHEMERIS',
                'ORBIT  DAY   ORBIT START   ORBIT END    SUN ENTRANCE    SUN EXIT
                TCH      ROLL       ALPHA       DELTA') (PAGE, A, SKIP(1), A);
90                      RETURN;
91              END;
```

/* AS&E OSO-D PROGRAMS // ASPECT-EPHEMERIS SUMMARY LISTING */

```
               ASIN.. PROCEDURE(X),.
                       RETURN (ATAN (X  / SQRT (1. - X * X))),.
               END,.
               ACOS.. PROCEDURE (X),.
                       ANGLE = ATAN (SQRT (1.0 - X*X), X);
                       RETURN (ANGLE),.
               END,.
               END,.
```

END