INPE-516-RI/220

TÍTULO: X-RAYS MEASUREMENTS IN THE BRAZILIAN MAGNETIC ANOMALY.

PROJETO: TELA

AUTOR: I.M. Martin

PUBLICADO EM AGÔSTO DE 1974

Coordenador

cc.: 03

X-RAYS MEASUREMENTS IN THE BRAZILIAN MAGNETIC ANOMALY

by

I.M. Martin

Instituto de Pesquisas Espaciais - INPE

São José dos Campos - São Paulo - Brasil

ABSTRACT

Measurements of x-rays in the range 20 - 150 KeV were made utilizing two balloons launched from São José dos Campos (Brazil) in July 1968. The primary objective of the experiment was to determine the additional x-ray flux from trapped electrons interacting with the atmosphere in the region of the Brazilian Magnetic Anomaly. A discussion is presented of secondary, galactic and additional fluxes variation along the balloons trajectories. A special telemetry system was developed to permit data collection along several thousand kilometers of the flight which was made using the westerlies of the Southern hemisphere winter.

The magnetic field of the Earth presents, on account of its inclination and of the excentricity due to the bi-polar terms, an area of minimum value located on the East Coast of South America. This fact induces important consequences on the behaviour of the particles trapped in the internal part of the radiation belts. The latter have their motions round the Earth determined at first approximation, by the 3 adiabatic invariants: they travel on constant L shells and their mirror-points are located on constant B values. The particles from the inner part of the belts come at a minimum distance from the Earth near the mirror points in the anomaly area. They thus undergo an interaction with the higher layers of the atmosphere at the end of which they are either absorbed, either scattered in the second case they have new mirror points at lower altitudes. This phenomenon is undergone at each new crossing of the anomaly and leads to a continual precipitation of particles in this area (ROEDERER, 1966).

The experiment described was intended to study from a balloon the x-ray flux in this zone in order to show the photon emissions. Thanks to their bremsstrahlung due to the precipitations of electrons from the belts into the high atmosphere, it was possible to evaluate the importance of the phenomenon. This experience should enable us to appreciate the importance of this process which rules the dynamic of the internal part of the radiation belts ($L = 1,1$ to $L = 1,5$).

THE EXPERIMENTAL METHOD

The main difficulty in this experiment is that the anomaly is located in its largest part, over the South Atlantic. Several tests from satellites have allowed to scan the region where the flux of particles trapped at low altitude is maximum. The setting of this maximum is given by the value of the magnetic field which settles, for each L layer, the point of minimum altitude and by the flux os particles which grows sharply with L. This explains why the center of the magnetic anomaly does not correspond with that of the flux of particles. Figure 1 shows the position, away from the Brazilian coast, of the center of this area.

The experience consisted in making a detector cross the anomaly. We used a balloon and thanks to the favorable winds of austral winter, we were able to measure during the same flight the x-ray flux in different points so as to prove the contribution of precipitated particles. On the other hand this method eliminated the causes of errors due to differences of instruments and distant experiences. During the flight the galactic composant will be a constant, the secondary global component will be a function of the cutt-off rigidity. All others variations will thus be due to the additional flux created by the electrons bremsstrahlung.

On account of the width and position over the ocean of the interesting area which prevents from using a on the spot reception station we had to work out a device transmitting informations to great distances and enabling us to know the position of the balloon. We used a detector made up with a NaI scintillator with a Be window associated with a photomultiplicator and tapped with a Pb, Ta, Sn collimator. The whole system had a geometrical factor of 10 cm^2 x str. The impulsions of the photomultiplicator were analyzed throught 3 channels = 20 - 50 KeV, 50 - 80 KeV, 80 - 150 KeV.

The position of the ballon could be computed from a solar sensor made up with a photoresistance the answer of which is a fonction of the height of the sun. This apparatus was similar to the ones used for Eole and Ghost Projects and gave the position with an error of one to two degrees.

The informations from the detector, the solar sensor and the altitude data from the alphatron were turned into impulsions, stored, transleted into binary langage and issued, one after the other, by a transmitter working on an all-or-nothing basis and on a frequency of 15 MHz. This telemetry (PCM-CW) emited a train of five ten-bits words. To obtain a minimum perturbation at the reception the transmitting frequency choosen was 1 bit/sec, which gave a complete period, with the synchronism pulses, for each 72 seconds. This sampling frequency was quite satisfactory since the phenomena differs but slowly in time. Figure 2 shows a block diagram of the apparatus.

RESULTS

A balloon carrying the above mentioned device was launched on July 23, 1968 from São José dos Campos (Brazil) (Latitude 23^{o}S, Longitude 46^{o}W, L = 1,12) at 03.17 hour (Local time). The experiment was satisfactory and datas were gathered till 17.42 hour in spite of interruptions due to bad recepting conditions. The trajectory of the balloon as computed during the beginning of the flight by radar, and then by the Solar sensor, was South-East. The end of reception took place on a point located at longitude: 30^{o}W, latitude 30^{o}S, L = 1,25. The distance between the initial and final points was 1.900 km in straight line. The estimated maximum level was 3,5 mb at the beginning of the flight; afterwards the balloon went down slowly to the 10 mb level at the end of the journey. Yet the uncertainty on a strict calibration prevents us from giving a rigorous determination of these results, though permitting comparisons between several points. The datas obtained can be found in Figure 3.

On reaching the maximum level at the beginning of the flight the flux values in the 3 energy channels were:

20 - 50 KeV	8,1 x 10^{-3} photon/cm^{2} x KeV x str x sec.
50 - 80 KeV	3,4 x 10^{-3} photon/cm^{2} x KeV x str x sec.
80 - 150KeV	2,4 x 10^{-3} photon/cm^{2} x KeV x str x sec.

At the end of the flight these values were:

20 - 50 KeV	1,0 x 10^{-2} photon/cm^2 x KeV x str x sec.
50 - 80 KeV	4,6 x 10^{-3} photon/cm^2 x KeV x str x sec.
80 - 150KeV	3,6 x 10^{-3} photon/cm^2 x KeV x str x sec.

The values must at first be corrected in function of the loss of altitude. Therefore we computed the increase by reference with measures at the same level reached during the climbing; we obtained the following ratios:

20 - 50 KeV: 30%

50 - 80 KeV: 22%

80 - 150KeV: 19,5%

The effective cutt off rigidity changed during the flight from 12,76 GV (start) down to 9,28 GV (end of transmission) (SHEA, 1966). The obtained spectrum was compared with results from similar experiments under other latitudes: Peterson's measurements (40^{O}N) and ours at 46^{O}N. (PETERSON, 1967).

The variations found on the highest two energy channels can easily enough be accounted for by the unconstant cutt-off energy. Though the differences in the shape of the spectrum with latitude are not quite understood, it seems that a part of the additional flux (10%) is not due to variations of latitude and is most probably produced by precipitations of particles. We were able to determine only upper limit of this additional flux on account of the uncertainty of the altitude determination. In the 20 - 50 KeV channel this value is at the top of the atmosphere, 4×10^{-3} photon/cm^2 x KeV x str x sec.

ACKNOWLEDGEMENTS:

This work was realized in collaboration between the Instituto de Pesquisas Espaciais (INPE) (São José dos Campos, São Paulo, Brasil) and Centre d'Etude Spatiale des Rayonnements (Toulouse, France). It was supported by contract CNES nº 238 and DRME Nº 68-34-270--00-480-75-01. We are indebted to CLBA from CNES (France) for his assistance and support for balloon launching.

REFERENCES

HESS, W.N., J.Geophys.Res., 68, 667, 1963.

PETERSON, L.E., Jerde, R.L., Jacobson, A.S., AIAA Journal 5, 1921, 1967.

ROEDERER, J.G., Space Research VI, 117, 1966.

SHEA, M.A., Smart, D.F., Space Research VI, 177, 1966.

FIGURE CAPTIONS

Figure 1 Flux of particles in Southern hemisphere after Discoverer 31 (E_p > 2 MeV, E_e > 100 KeV), (HESS, W.N., 1963).

Figure 2 Block diagram of experiment.

Figure 3 Counting from five channels; C_1: 20 - 50 KeV, C_2: 50 - 80 KeV, C_3: 80 - 150 KeV, C_4: Pressure sensor and C_5 sensor solar.

Figure 4 Additional flux with altitude correction.

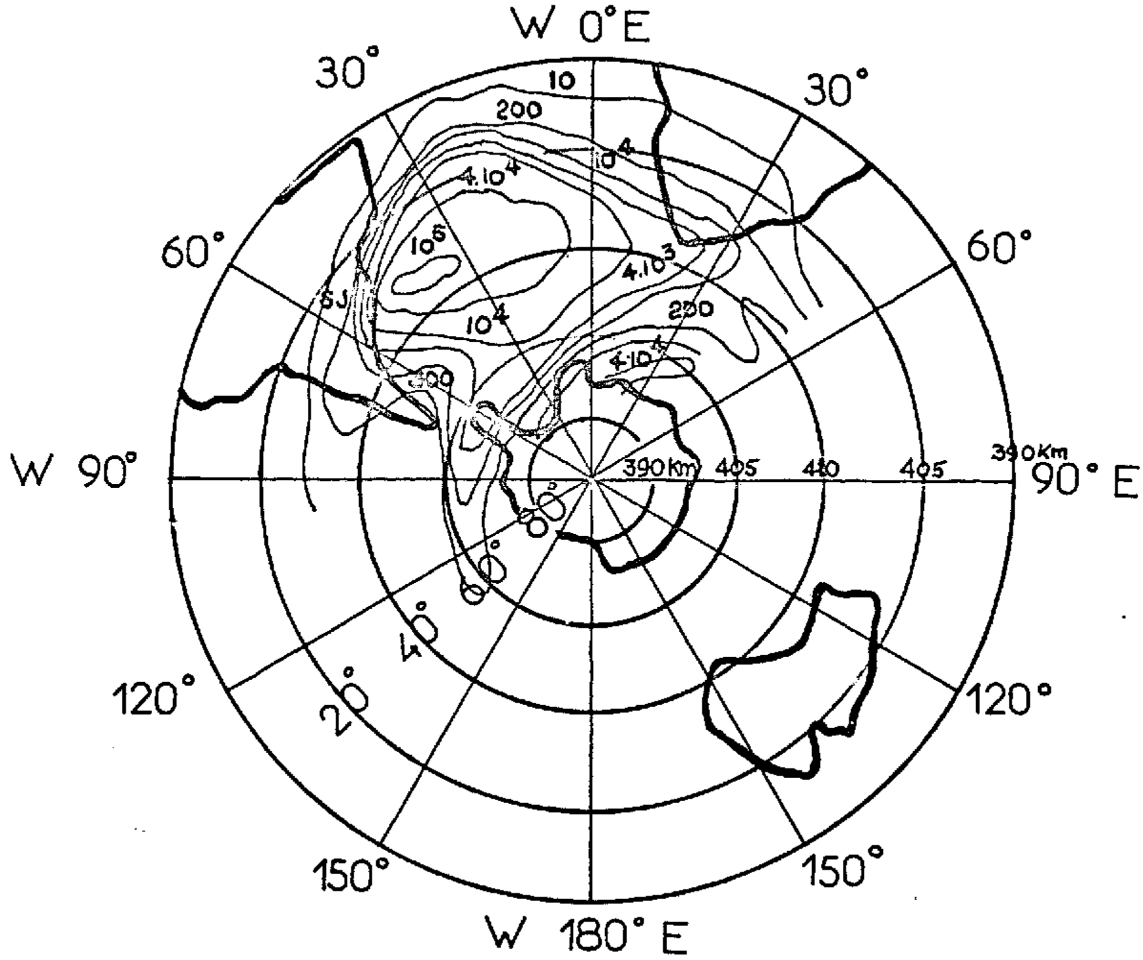
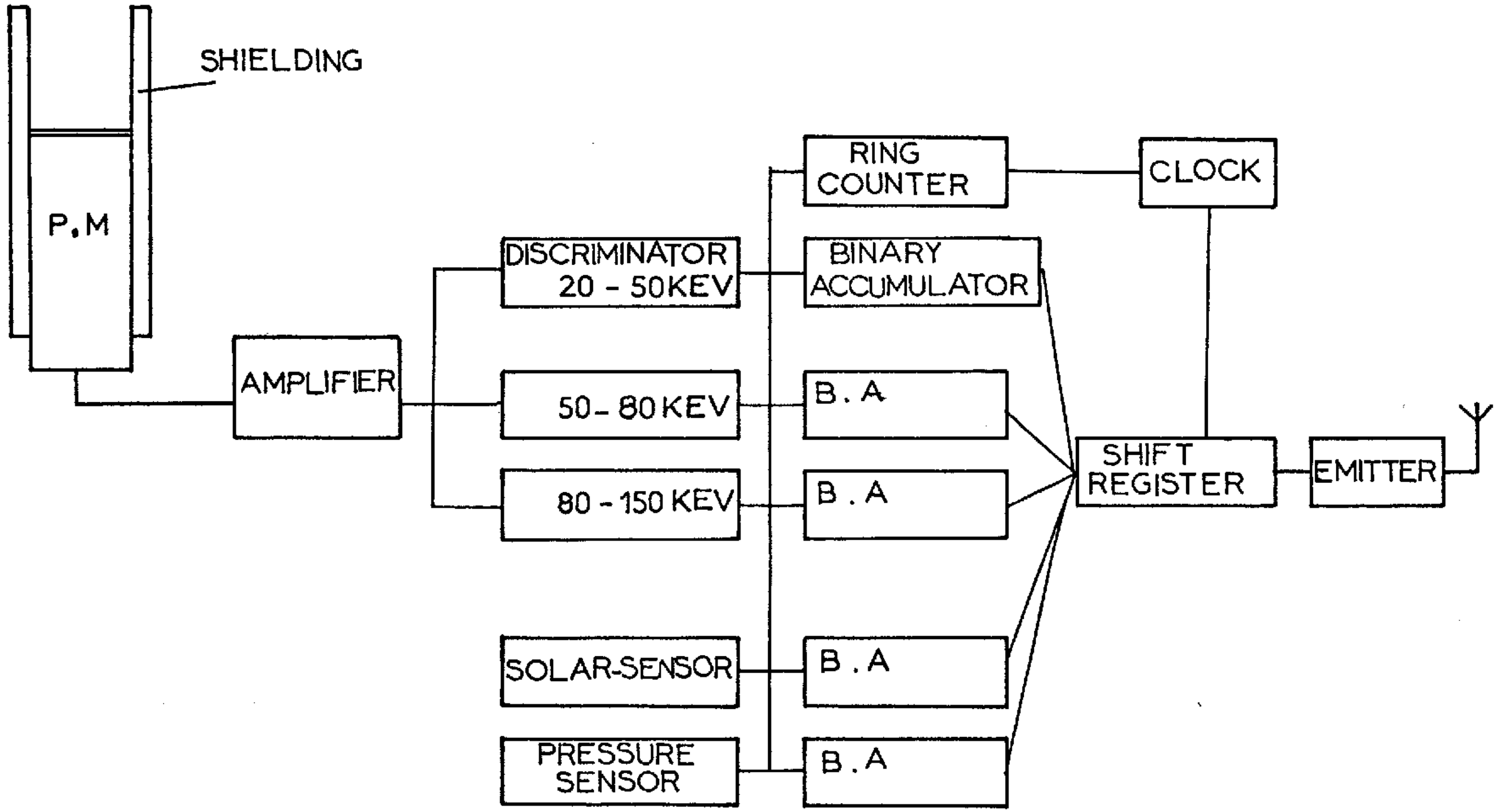
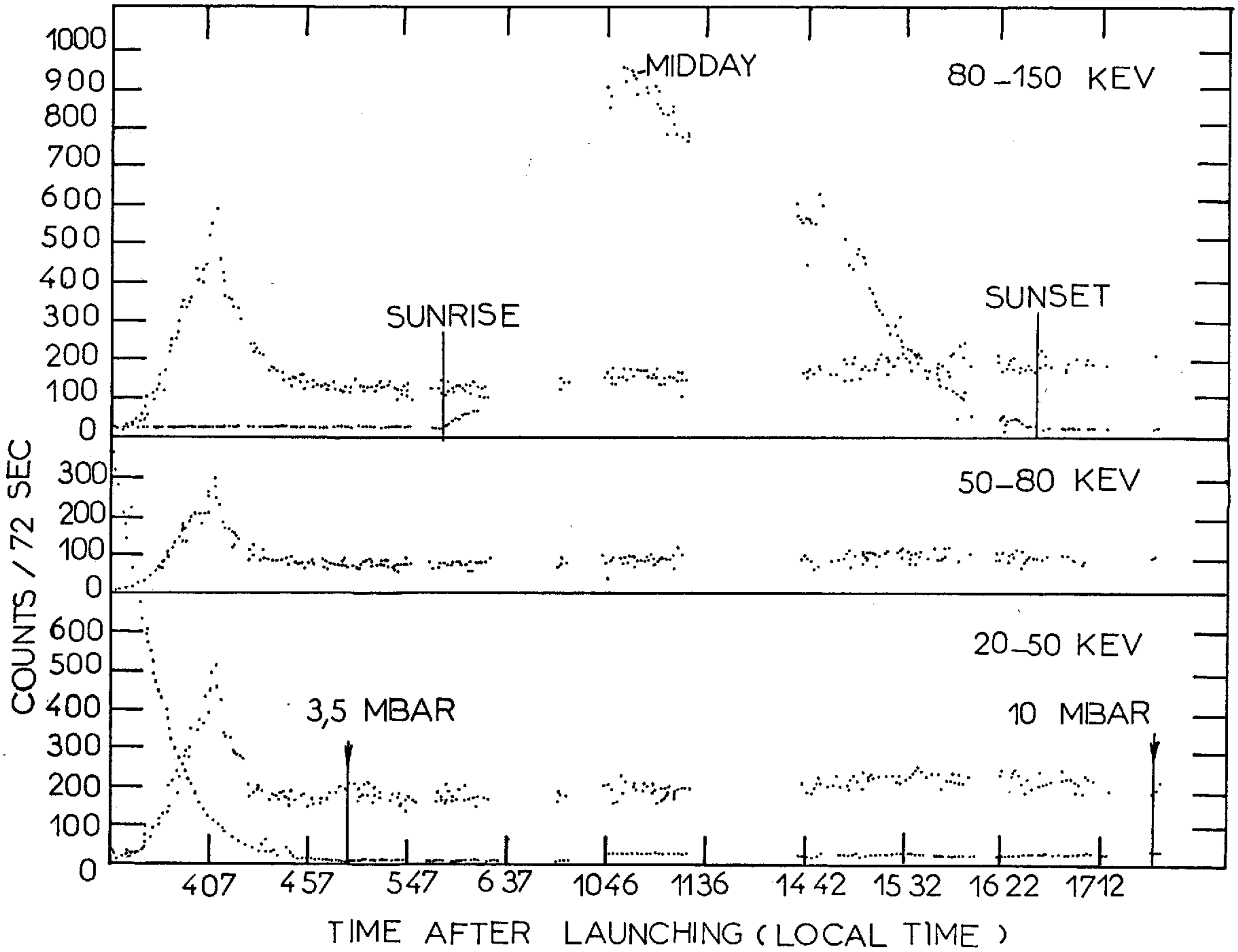

W 0°E
30°
30°
60°
60°
W 90°
90° E
120°
120°
150°
150°
W 180° E
10
200
10^4
4.10^4
10^6
4.10^3
10^4
200
4.10^4
200
SJ
390Km
405
410
405
390Km
80°
60°
40°
20°

Figure 1



SHIELDING
P.M
AMPLIFIER
DISCRIMINATOR 20 - 50KEV
50- 80KEV
80 - 150 KEV
SOLAR-SENSOR
PRESSURE SENSOR
RING COUNTER
BINARY ACCUMULATOR
B . A
B . A
B . A
B . A
CLOCK
SHIFT REGISTER
EMITTER

Figure 2


MIDDAY
80–150 KEV
SUNRISE
SUNSET
50–80 KEV
20–50 KEV
3,5 MBAR
10 MBAR
COUNTS / 72 SEC
1000
900
800
700
600
500
400
300
200
100
0
407
457
547
637
1046
1136
1442
1532
1622
1712
TIME AFTER LAUNCHING (LOCAL TIME)

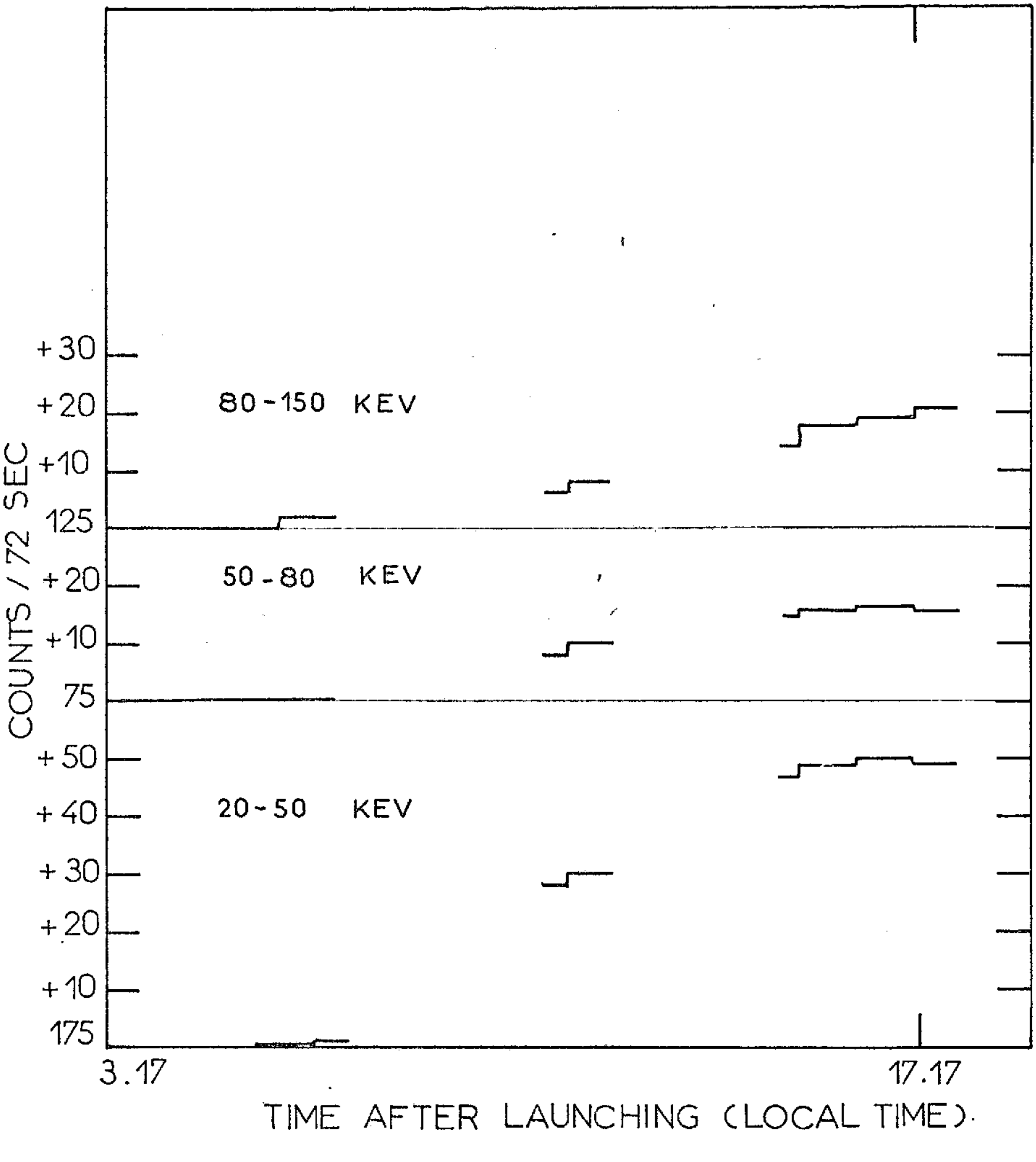

+30
+20
+10
125
+20
+10
75
+50
+40
+30
+20
+10
175
80-150 KEV
50-80 KEV
20-50 KEV
COUNTS / 72 SEC
3.17
17.17
TIME AFTER LAUNCHING (LOCAL TIME)

Figure 4