

N 68-25688

FACILITY FORM 602

(ACCESSION NUMBER) 32

(PAGES) 32

(NASA CR OR TMX OR AD NUMBER) NASA-CR#89397

(THRU) 1

(COP) 29

(CATEGORY) 29

GPO PRICE \$ _____

CFSTI PRICE(S) \$ _____

Hard copy (HC) _____

Microfiche (MF) _____

ff 653 July 65

Department of Physics and Astronomy
THE UNIVERSITY OF IOWA
 Iowa City, Iowa

U. of Iowa 67-51

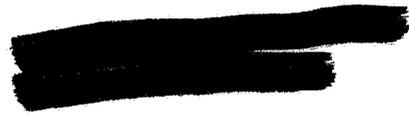
Observations of Low Energy (~ 0.5 MeV)
Trapped Protons with Injun IV

by

S. M. Krimigis

July 1967

Presented at the Advanced Study Institute, "Earth's Particles
and Fields", Freising, Germany, July 31--August 11, 1967.



ABSTRACT

The detector complement of the University of Iowa satellite Injun IV, which was launched on 21 November 1964 into a high latitude --low altitude orbit, includes a 25 micron totally depleted surface barrier detector with four discrimination levels, two of which are sensitive to protons in the energy interval $0.52 \leq E_p \lesssim 4$ MeV (channel A) and $0.90 \leq E_p \leq 1.8$ MeV (channel B), and insensitive to electrons of any energy. An analysis of the data for the period 1 March--17 April 1965 has shown the following. (1) Maximum intensities occur at $L \simeq 3.05$ and $|\vec{B}| = 0.16$ gauss of 1.5×10^5 (cm² sec sr)⁻¹ for A and of 4×10^4 (cm² sec sr)⁻¹ for B. (2) The intensity maximum moves to higher L values as $|\vec{B}|$ increases. (3) Time variations generally occur for $L \gtrsim 4.5$ and $|\vec{B}| \gtrsim 0.30$, except during major magnetic storms when time variations are observed for $L \gtrsim 2.2$. (4) The energy spectrum may be described by $dj/dE = K/E_0 e^{-E/E_0}$, with E_0 ranging from ~ 0.38 at $L = 2.1$ to 0.13 MeV at $L \approx 4.8$. (5) The boundary is located at $L \sim 5.6$ for protons of $E_p \gtrsim 0.52$ MeV and at $L \sim 4.8$ for $E_p \gtrsim 0.90$ MeV. The data are compared to the model of NAKADA et al. (1965) and found to agree qualitatively with their predictions. Following the 17 April 1965 magnetic storm, the distribution of 0.5 MeV protons became bifurcated with a primary intensity peak at $L \simeq 2.75$ and a secondary one at $L \sim 3.5$.

INTRODUCTION

Since the discovery of the low energy (~ 0.5 MeV) protons trapped in the geomagnetic field by DAVIS and WILLIAMSON (1963) and BAME et al. (1963), several measurements have been reported on the intensities, angular distributions, energy spectra, and time variations of such protons (KATZ, 1965; FILLIUS, 1966; KRIMIGIS and ARMSTRONG, 1966; MIHALOV and WHITE, 1966; ARMSTRONG and KRIMIGIS, 1967). The present investigation extends the measurements to high latitudes ($\sim 80^\circ$) and low L values ($L \gtrsim 1.1$) with data obtained from the University of Iowa polar-orbiting Injun IV satellite. Preliminary data from this experiment have been reported previously (KRIMIGIS and VAN ALLEN, 1965; KRIMIGIS, 1967a, b). In the following, constant intensity contours in $|\vec{B}| - L$ space are presented for protons in the energy intervals $0.52 \leq E_p \leq 4$ MeV and $0.90 \leq E_p \leq 1.8$ MeV. The energy spectrum parameter E_o is computed as a function of L and it is shown that a major departure from the $E_o \propto L^{-3}$ law is found for $L \lesssim 3.5$ at $|\vec{B}| = 0.19$ gauss. The data are compared with those of VERNOV et al. (1967) and MIHALOV and WHITE (1966), at points in $|\vec{B}| - L$ space where the measurements overlap, and are found to agree to within experimental errors. Finally, data are presented on the redistribution of protons in the radiation zones following the 17 April 1965 magnetic storm.

THE DETECTOR

The Injun IV detector relevant to these observations is a totally depleted silicon one of the surface barrier kind in the form of a thin circular disc, whose thickness is 25 microns and whose frontal area is $1.75 \pm 0.2 \text{ mm}^2$ (Nuclear Diodes, Inc.). The detector is located inside a conical collimator with a full vertex angle of 40° and is otherwise shielded by a minimum of 10.2 g/cm^2 of brass, which corresponds to the range of 95 MeV protons. To shield against sunlight a nickel foil whose thickness is 0.21 mgm/cm^2 of air equivalent for α -particles, was placed in front of the detector. Four electronic discrimination levels are provided. The first two (channels A and B) are sensitive to protons and heavier nuclei and the last two (channels C and D) are sensitive only to particles heavier than deuterons (Table I). The scheme for energy discrimination is illustrated in Figure 1. It is noted that the maximum energy that an electron may leave in the detector is nominally 60 keV and that it takes seven-fold coincidence of 60 keV electrons to produce a count in channel A. The thin detector, coupled with a double-delay line clipped pulse of 200 nanoseconds full width, renders the detector insensitive to electrons of any

Table I

Characteristics of the Injun IV Detectors

Detector	Unidirectional Geometric Factor cm ² steradian	Omnidirectional Geometric Factor cm ²	Particles to Which Sensitive	Dynamic Range
A	0.0064 ± 0.0007	---	Protons: 0.516 ≤ E _p ≤ 4* MeV Electrons: None	From inflight source to 10 ⁶ c/sec
B	0.0064 ± 0.0007	---	Protons: 0.90 ≤ E _p ≤ 1.8* MeV Electrons: None	"
C	0.0064 ± 0.0007	---	α-Particles: 2.09 ≤ E _α ≤ 15* MeV	"
D	0.0064 ± 0.0007	---	α-Particles: 3.89 ≤ E _α ≤ 7* MeV	"
SpB	---	~ 0.4	Protons: E _p ≥ 70 MeV Electrons: Insensitive except via bremsstrahlung for E _e ≥ 1 MeV	From galactic cosmic ray rate of 2 c/s to 2 x 10 ⁵ c/sec

1* Upper limit for vertical incidence only; the corresponding limits for incidence at 20° to the collimator axis are 4.2 MeV, 1.9 MeV, 1.8 MeV, and 8 MeV for A, B, C, and D, respectively.

2 A, B, C, D, correspond to different electronic discrimination levels in the same basic detector.

energy. The electron insensitivity and the calibration methods that have been used are identical to those described in detail elsewhere (KRIMIGIS and ARMSTRONG, 1966). Knowledge of the proper operation of the instrument is assured through an inflight ${}_{95}^{241}\text{Am}$ source of 5.477-MeV α -particles which was gold plated to obtain a falling spectrum between 0.50 to 3.9 MeV. Thus any change in the detector characteristics and/or drift in the discrimination levels would be immediately noticeable. No such change in the background rate (over the polar caps) by as much as $\pm 5\%$ has been observed during the period of the observations on which the present paper is based.

DATA ANALYSIS

The Injun IV satellite was launched on 21 November 1964 into a nearly polar orbit of 81° inclination, with initial apogee altitude of 2502 kilometers and perigee altitude of 527 kilometers. The satellite is equipped with a permanent magnet and energy-dissipating hysteresis rods so that it will maintain a particular axis continuously aligned with the local geomagnetic field vector. Due to a large initial angular velocity at launch and weak damping, magnetic alignment did not occur until the latter part of February

1965. Thereafter, the axis of the detector collimator was maintained continuously perpendicular ($\pm 10^\circ$) to the local magnetic field vector so that the detector was receiving particles whose pitch angles were $90^\circ \pm 30^\circ$. The primary body of data reported in this paper was obtained during the period 1 March to 17 April 1965.

All telemetered data from the satellite are merged with the orbit parameters $|\vec{B}|$, L , and local time and subsequently sorted into subsets specified by selected ranges of $|\vec{B}|$ and L . The L interval used in this study is 0.1 and the $|\vec{B}|$ interval 0.02 gauss. For a given L interval, the directional intensity perpendicular to \vec{B} is plotted as a function of $|\vec{B}|$. From a family of such plots, a graphical display is made of constant intensity contours in $|\vec{B}|$, L space.

OBSERVATIONS

1. Magnetically Quiet Period. Figure 2 shows the counting rate vs invariant latitude Λ in a typical satellite pass for channels A and B. We observe the following: (a) The maximum intensity occurs at $\Lambda \approx 55^\circ$ or $L = 3.05$ for both channels A and B. (b) The trapping boundary for $0.52 \leq E_p \leq 4$ MeV protons is located at $\Lambda \approx 65^\circ$ ($L \approx 5.6$) and for $0.90 \leq E_p \leq 1.8$ MeV at $\Lambda \approx 63^\circ$ ($L \approx 4.8$), at a

magnetic local time of 4.7 hours. (c) The ratio of the counting rates of A to B increases for $\Lambda > 50^\circ$ or $L > 2.5$ and apparently decreases for $L < 2.5$. Revolution 1818 is typical of many such revolutions in the time interval 1 March to 17 April 1965, a period of relatively low magnetic activity. The data from all such satellite passes during the forementioned period have been averaged for a particular $|\vec{B}|, L$ group and the resulting plots have been used in constructing constant intensity contours which are shown in Figures 3 and 4.

It can be seen from Figure 3 that the maximum intensity for $0.52 \leq E_p \leq 4$ MeV proton occurs at $L \simeq 3$ at $|\vec{B}| \simeq 0.19$ gauss and that the intensity maximum moves to higher L values as $|\vec{B}|$ increases. It is also observed that in the region bounded by $L \gtrsim 4.5$ and $|\vec{B}| \gtrsim 0.30$ the constant intensity contours show abrupt changes in form with small variations in $|\vec{B}|$ and L. In several cases the intensity is a multiple-valued function of $|\vec{B}|$ for a constant L. The data suggest that this might be a region in which time variations are important. A detailed examination has revealed that the above impression is correct, namely, in a given $|\vec{B}|, L$ group where $L \gtrsim 4.5$ and $|\vec{B}| \gtrsim 0.30$ the intensity changes rapidly as a function of time and responds promptly to time variations in the geomagnetic field.

Figure 4 shows constant intensity contours for protons of energy $0.90 \leq E_p \leq 1.8$ MeV. We observe that the general profile is similar to that of the 0.52 MeV protons, with the intensity maximum moving to higher L values as $|\vec{B}|$ increases. It is apparent that at $L \gtrsim 4.5$ and $|\vec{B}| \gtrsim 0.33$ fluctuations in the intensity occur and are probably attributable to time variations in this region.

In Figure 5, a profile in L at a constant value of $|\vec{B}| = 0.19 \pm 0.01$ is shown for both channels A and B; the data are averaged over the period 1 March to 17 April 1965. It is seen that the features of the averaged L profile are essentially identical to those observed in the single pass shown in Figure 2. The intensity of $0.52 \leq E_p \leq 4$ MeV protons varies from ~ 50 $(\text{cm}^2 \text{ sec sr})^{-1}$ at $L = 1.15$ to 1.24×10^5 $(\text{cm}^2 \text{ sec sr})^{-1}$ at $L = 3.05$, and that of $0.90 \leq E_p \leq 1.8$ MeV varies from ~ 40 $(\text{cm}^2 \text{ sec sr})^{-1}$ at $L = 1.25$ to 3.56×10^4 $(\text{cm}^2 \text{ sec sr})^{-1}$ at $L = 2.95$. The position of the high latitude boundary is located at $L = 5.7$ and $L = 4.7$ for protons of 0.52 MeV and 0.90 MeV energy, respectively, if we adopt an arbitrary cutoff value of 1 count/sec which corresponds to a flux of 155 $(\text{cm}^2 \text{ sec sr})^{-1}$. We note that the ratio A/B has a minimum value at $L \approx 2.15$ and that it increases monotonically at higher and lower values of L. The increase of the ratio below $L = 2.15$ is in no way correlated to the Starfish electrons, since the peak

intensity of these electrons is located at an L-value of 1.3 to 1.4, as measured by a 302 G.M. tube on the same satellite. The significance of the change in the ratio A/B will be discussed in a later section.

Finally we observe from Figures 3 and 4 that for $|\vec{B}| \lesssim 0.22$ the L-value at which the maximum intensity occurs does not decrease as $|\vec{B}|$ decreases. This result indicates that the position of the intensity maximum occurs at the same L value at the equator and at high latitudes where $|\vec{B}| \leq 0.20$. Such impression is verified by the observations of KIRMIGIS and ARMSTRONG (1966) and ARMSTRONG and KIRMIGIS (1967), using data from the Mariner IV and Explorer 33 spacecrafts, respectively, taken close to or at the equator with similar detectors.

2. Time Variations. The observations presented so far were obtained during a magnetically quiet period in the course of which the proton intensities at a given point in $|\vec{B}|, L$ space were constant to within $\pm 10\%$ (except for $L > 4.5$ and $|\vec{B}| \geq 0.30$). On 17 April 1965 there occurred a sudden commencement at 1312 UT followed by a magnetic storm with $\Delta |\vec{B}| \sim 160$ gamma at the main phase maximum, which took place at ~ 0830 UT on 18 April. The distribution of 0.52 MeV and 0.90 MeV protons was severely disturbed after

the 17th of April. Figure 6 shows four characteristic passes of Injun IV illustrating the change in the distribution. The first pass was taken prior to the sudden commencement, while the second was taken at the time of the main phase maximum; the 3rd and 4th passes were taken two and twelve days, respectively, after the main phase maximum. We observe the following: (a) The boundary moved from its pre-storm value of $L \sim 5.8$ to $L \sim 4$ during the main phase, and back to $L \sim 5.5$ on April 20. (b) The intensity maximum changed from a broad peak centered at $L \simeq 3.0$ to a narrow peak centered at $L \simeq 2.75$, while the intensity at the peak increased by $\sim 50\%$. (c) On 20 April and at $L \sim 3.5$ there is evidence of the presence of a secondary peak which, on 30 April, appears to be a semi-permanent feature of the proton distribution. Analogous behavior was observed for the 0.9 MeV protons, except that the evidence for a secondary peak in the intensity is not convincing. The distribution shown for 30 April persisted until 15 June, at which time another magnetic storm of moderate magnitude ($\Delta |\vec{B}| \simeq 100$ gamma) changed the distribution to one similar to that existing prior to 17 April.

DISCUSSION

1. Comparison with Other Observers. The data presented in the previous sections have been compared to those of VERNOV et al. (1967) and MIHALOV and WHITE (1966). The data of Vernov were taken in February and July 1964 using a solid state detector to measure protons in the interval $0.90 \leq E_p \leq 5.5$ MeV. Those of Mihalov and White were taken in August 1964. Representative points are compared in Table II. It is seen that although the observations were made at different time periods, the agreement is quite good.

2. Energy Spectrum. Figure 7 shows a plot of E_0 vs L for the time periods 1 March to 17 April and 25 April--31 May 1965. At the top of the figure is plotted the ratio of A/B from which the values of E_0 were derived. We observe that the slope of the ratio undergoes a change in sign at $L \simeq 2.15$ and hence the energy spectrum undergoes a radical change at this value of L . Using the two data channels and making the assumption that the spectrum is falling monotonically in the interval 0.52 to 0.90 MeV, we may compute a value for the parameter E_0 in the expression $\frac{dj}{dE} = \frac{K}{E_0} e^{-E/E_0}$. The above assumption is known to be correct for $L \gtrsim 2.1$ (MIHALOV and WHITE, 1966). There are indications, however, that the differential spectrum is rising

Table II

Comparison with Other Measurements

$L, \vec{B} $	<u>Vernov et al. (1967)</u>	<u>Mihalov and White (1966)</u>	<u>This Experiment</u>
	$(0.9 \leq E_p \leq 5.5 \text{ MeV})$	$(0.55 \leq E_p \leq 1.2 \text{ MeV})$	$(0.9 \leq E_p \leq 1.8 \text{ MeV})$
2.0, 0.15	5×10^3	---	4.7×10^3
2.0, 0.20	1.5×10^3	---	1.7×10^3
1.8, 0.20	1×10^3	---	0.9×10^3
1.6, 0.15	3×10^3	--	2.3×10^3
3.0, 0.20	---	8×10^4	1.24×10^5 ($0.52 \leq E_p \leq 4 \text{ MeV}$)

in the interval 0.52 to 0.90 MeV with the peak of the spectrum located at 2.5 to 4 MeV for $1.6 \leq L \leq 2.0$ (FILLIUS, 1966; VERNOV et al., 1967). Since the energy passband of the first channel is $0.52 \leq E_p \leq 4$ MeV, we cannot reliably compute a value of E_o for L values in the interval $1.6 \leq L \leq 2$, although it might be possible to derive such values for $L \leq 1.5$ on the assumption that the spectrum is peaked at 4 MeV or higher. With the above limitations in mind, we may now examine the dependence of E_o on L .

a. Pre-Storm Spectrum. We observe that $E_o \propto L^{-3}$ holds in the interval $3.4 \leq L \leq 4.4$ only. The dependence of E_o on L for $L > 4.4$ is reminiscent of the similar behavior observed at the equator with Mariner IV (KRIMIGIS and ARMSTRONG, 1966). It may be connected with the observation that the spectrum is a double exponential described by two different values of E_o (HOFFMAN and BRACKEN, 1965).

For $L < 3.4$ the value of E_o deviates substantially from the $E_o \propto L^{-3}$ dependence. The behavior of E_o in this region may be understood on the basis of the theory of NAKADA et al. (1965). They show that for a given L at the equator, the value of E_o increases as the pitch angle increases, up to 90° . The increase in the value of E_o is quite pronounced at low L values ($L \sim 2$) but is not very important at

high L values ($L \sim 4-5$). The data then shows that in the range $3.4 \leq L \leq 4.4$, although we are sampling small equatorial pitch angles ($\alpha_0 \sim 10^\circ$), the dependence of E_0 on pitch angle is not pronounced and the $E_0 \propto L^{-3}$ law holds. At $L < 3.4$ we are observing particles whose equatorial pitch angles vary from $\sim 10^\circ$ at $L \sim 3.4$ to $\sim 30^\circ$ at $L \sim 2$ and hence are sampling regions where the pitch angle dependence of E_0 is strong and E_0 is expected to decrease.

A further check on this interpretation may be made by observing the dependence of E_0 on $|\vec{B}|$. If the theory of NAKADA et al. (1965) is correct, one would expect that at a constant L, E_0 would decrease as $|\vec{B}|$ increases, since the equatorial pitch angle of the particle decreases with increasing $|\vec{B}|$. Figure 8 shows a plot of E_0 vs $|\vec{B}|$ for $L = 3.05 \pm 0.05$. It is seen that E_0 decreases as $|\vec{B}|$ increases to ~ 0.21 but it begins to increase rapidly for $|\vec{B}| > 0.23$. This result is interpreted to mean that at values of $|\vec{B}| \lesssim 0.21$ we are seeing the expected behavior as predicted by NAKADA et al., but for $|\vec{B}| \gtrsim 0.23$ there are important atmospheric effects which cause the spectrum to become harder.

b. Post-Storm Spectrum. Figure 7 also shows the energy spectrum as a function of L for the steady-state proton distribution, following the magnetic storm of 17 April 1965. Several features

worthy of note are: (1) The $E_0 \propto L^{-3}$ law holds in the interval $2.6 \leq L \leq 4.5$, compared to the interval $3.4 \leq L \leq 4.5$ prior to the storm. (2) The value of E_0 is less than its pre-storm value for $3 < L \leq 4.5$, but is higher than the prestorm value in the interval $2.2 \leq L \leq 2.9$, and remains unchanged at $2.9 \lesssim L \leq 3$. (3) The spectrum for $L \lesssim 2.2$ has not changed from its prestorm value.

The interpretation of the change in the spectrum must take into account the variation in the intensities of both groups of particles, at 0.52 and 0.90 MeV. Further data show that, although one particle species may have behaved adiabatically in a given $|\vec{B}|, L$ interval, another species behaved non-adiabatically in the same $|\vec{B}|, L$ interval. Thus it appears that the effects of the storm and the subsequent ring current were, on the whole, non-adiabatic. A detailed study of the data during this storm will be published in a forthcoming paper (BURNS and KRIMIGIS, 1967).

Acknowledgements: The author is indebted to Dr. J. A. Van Allen for his continuous encouragement and useful discussions throughout this work. I thank Dr. T. P. Armstrong for assistance in various phases of the experiment and discussion of the results, and Mr. A. L. Burns for assistance in the data analysis and useful discussions regarding the

results. Development, construction, and preflight testing of the University of Iowa satellite Injun IV was performed under contract NAS1-2973 with the National Aeronautics and Space Administration/Langley Research Center. Analysis and publication have been performed in part under National Aeronautics and Space Administration grant NsG 233-62 and the Office of Naval Research contract Nonr 1509(06).

REFERENCES

- ARMSTRONG, T. P., and KRIMIGIS, S. M.: 1967, "Observations of Protons in the Magnetosphere and Magnetotail with Explorer 33", J. Geophys. Res. (to be published).
- BAME, S. J., CONNER, J. P., HILL, H. H., and HOLLY, F. E.: 1963, "Protons in the Outer Zone of the Radiation Belt", J. Geophys. Res., 68, 55-63.
- BURNS, A. L., and KRIMIGIS, S. M.: 1967, "Effects of the 17 April 1965 Magnetic Storm on Trapped Protons" (to be published).
- DAVIS, L. R., and WILLIAMSON, J. M.: 1963, "Low-Energy Trapped Protons", Space Research, 3, 365-375.
- FILLIUS, R. W.: 1966, "Trapped Protons in the Inner Radiation Belt", J. Geophys. Res., 71, 97-123.
- HOFFMAN, R. A., and BRACKEN, P. A.: 1965, "Magnetic Effects of the Quiet-Time Proton Belt", J. Geophys. Res., 70, 3541-3556.
- KATZ, L.: 1966, "Electron and Proton Observations," Radiation Trapped in the Earth's Magnetic Field, R. Reidel Publishing Co., Dordrecht-Holland, pp. 129-154.
- KRIMIGIS, S. M.: 1967a, "Bifurcation of the Outer Zone 0.5 MeV Proton Distribution Following the April 18, 1965 Magnetic Storm", Trans. Am. Geophys. Union, 48, 163 [Abstract].
- KRIMIGIS, S. M.: 1967b, "Observations of Trapped Protons with Injun-Explorer 25", Trans. Am. Geophys. Union, 48, 164 [Abstract].

- KRIMIGIS, S. M., and ARMSTRONG, T. P.: 1966, "Observations of Protons in the Magnetosphere with Mariner 4", J. Geophys. Res., 71, 4641-4650.
- KRIMIGIS, S. M., and VAN ALLEN, J. A.: 1965, "Observations of Geomagnetically Trapped Protons with Injun 4", Trans. Am. Geophys. Union, 46, 140 [Abstract].
- MIHALOV, J. D., and WHITE, R. S.: 1966, "Low-Energy Proton Radiation Belts", J. Geophys. Res., 71, 2207-2216.
- NAKADA, M. P., DUNGEY, J. W., and HESS, W. N.: 1965, "On the Origin of Outer-Belt Protons", J. Geophys. Res., 70, 3529-3532.
- VERNOV, S. N., VAKULOV, P. V., KUZNETSOV, S. N., LOGATCHEV, YU. I., NIKOLAEV, A. G., SOSNOVETS, E. N., and STOLPOVSKY, V. G.: 1967, Space Research VII, North Holland Publishing Company, pp. 577-586.

FIGURE CAPTIONS

- Figure 1. ΔE vs E curves for protons and α -particles incident vertically on a 25 micron silicon detector with a 0.21 mg/cm² nickel foil in front.
- Figure 2. Typical pass of the Injun IV satellite showing the counting rate due to protons in the specified energy intervals. The value of $|\vec{B}|$, magnetic local time, and Universal time are shown at the bottom.
- Figure 3. Constant intensity contours for $0.52 \leq E_p \leq 4$ MeV protons.
- Figure 4. Same as Figure 3 but for $0.90 \leq E_p \leq 1.8$ MeV protons.
- Figure 5. Counting rate profile at constant $|\vec{B}|$ in the indicated energy intervals. Note the change in the spectrum on either side of $L \simeq 2.15$.
- Figure 6. Redistribution of trapped protons during and after the 17 April 1965 storm. Evidence for the bifurcated distribution is clear on 20 April. The distribution persisted until 15 June 1965.
- Figure 7. Energy spectrum of trapped protons before and after the 17 April 1965 magnetic storm. Values of E_0 below $L = 2$ are ambiguous (see text).

Figure 8. Dependence of E_0 on $|\vec{B}|$. The effect of the atmosphere is clear for $|\vec{B}| \gtrsim 0.23$.

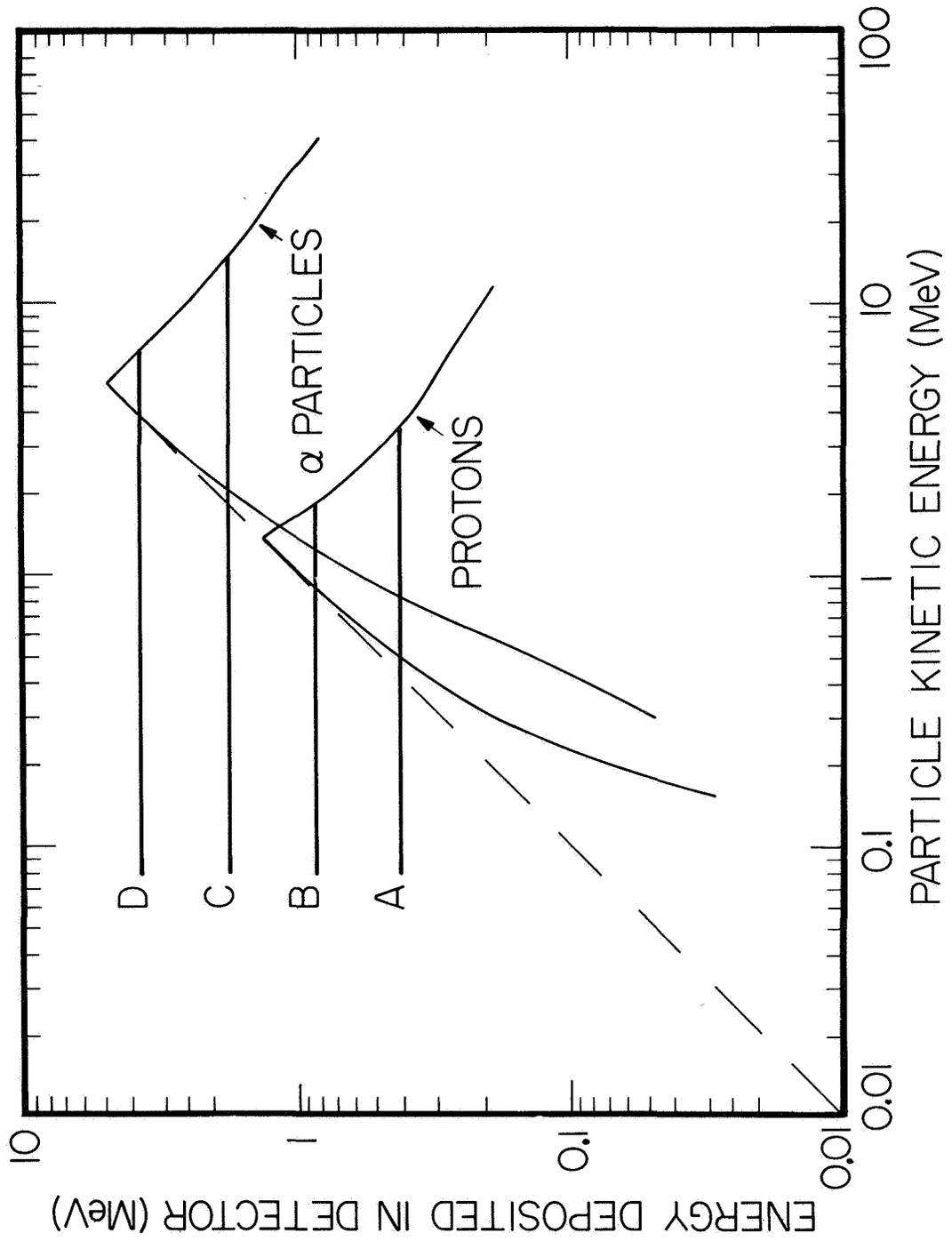


FIGURE 1

IN4 REV 1818 DATE 4/17/65 + - A Δ - B

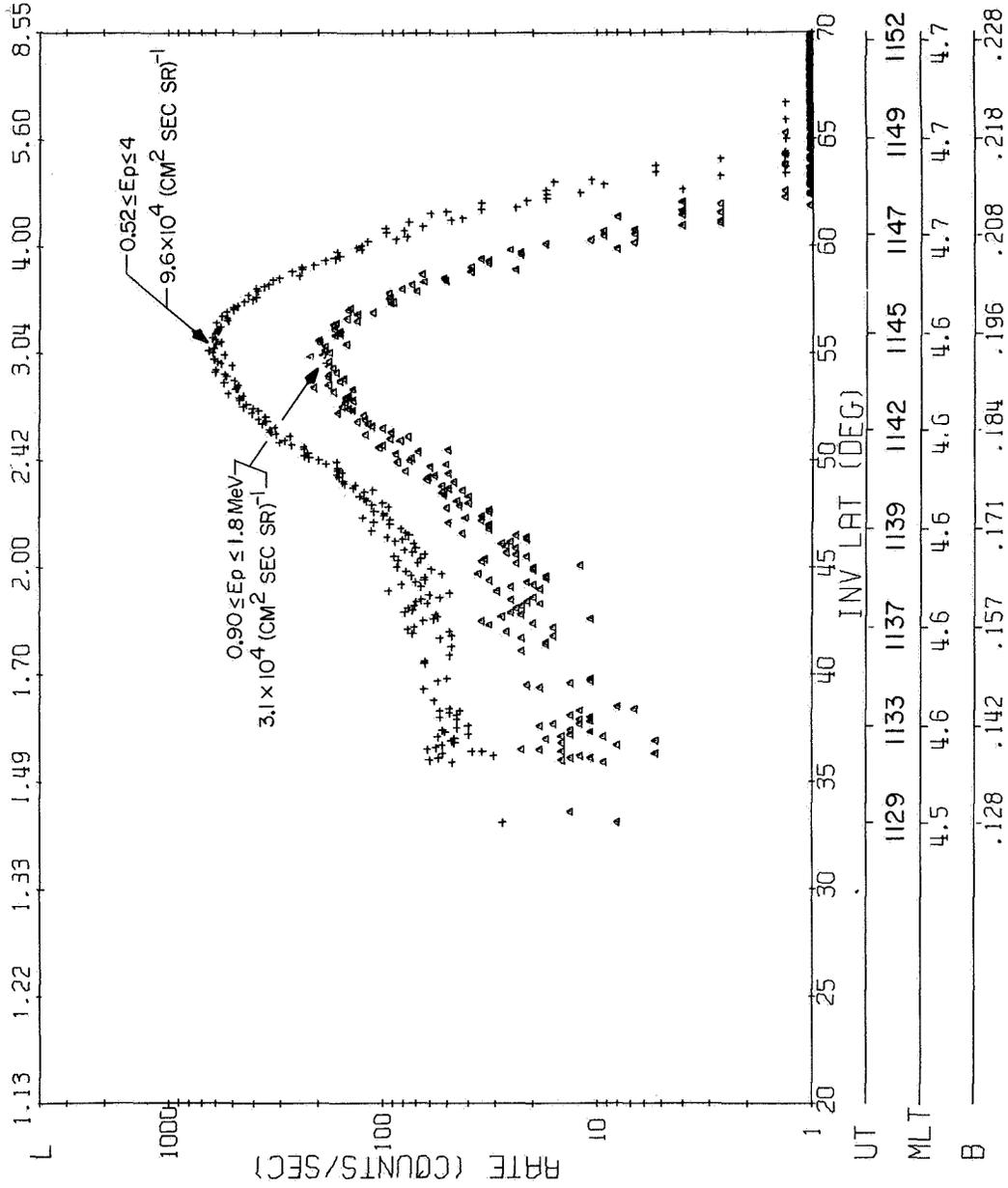


FIGURE 2

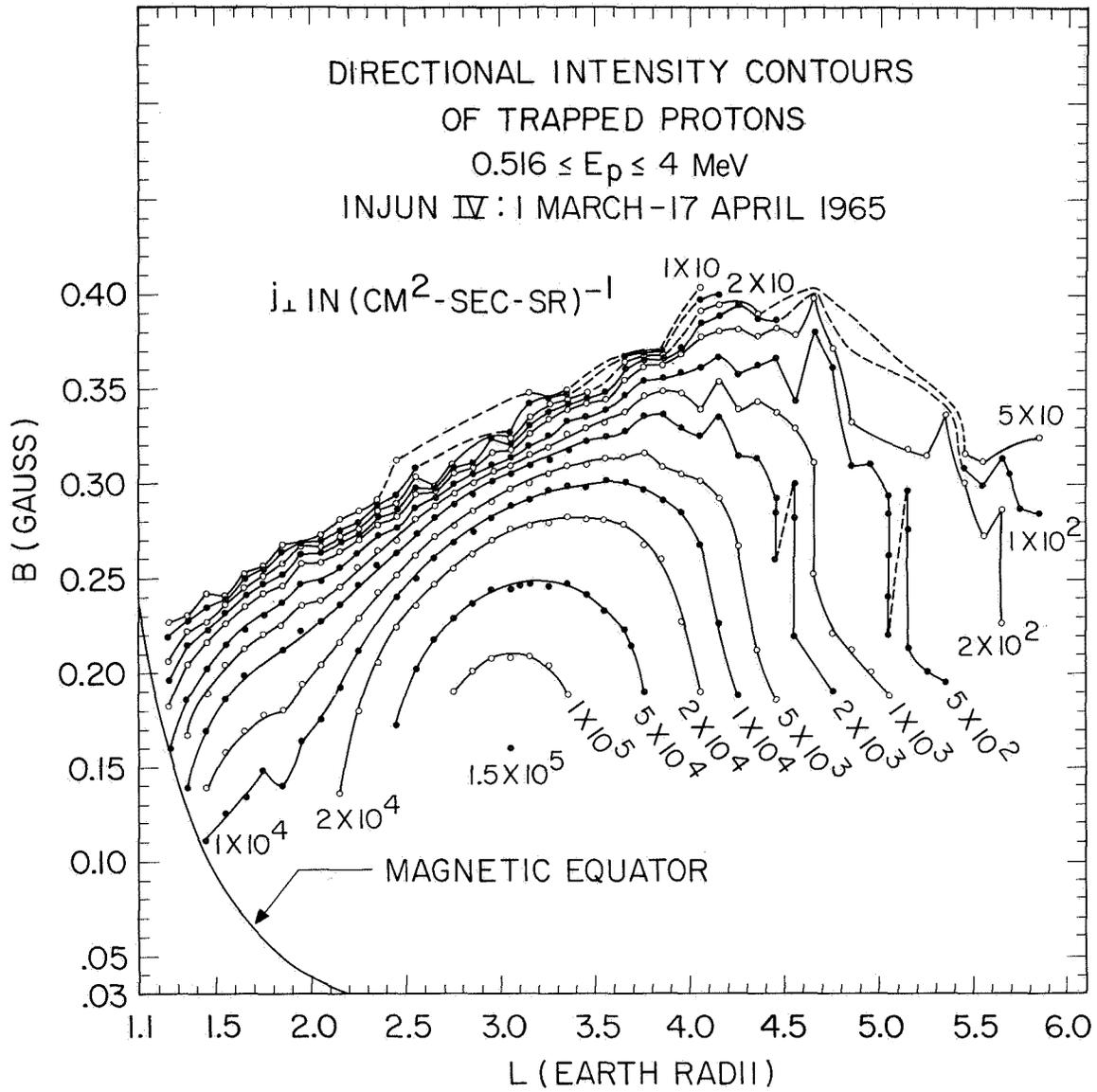


FIGURE 3

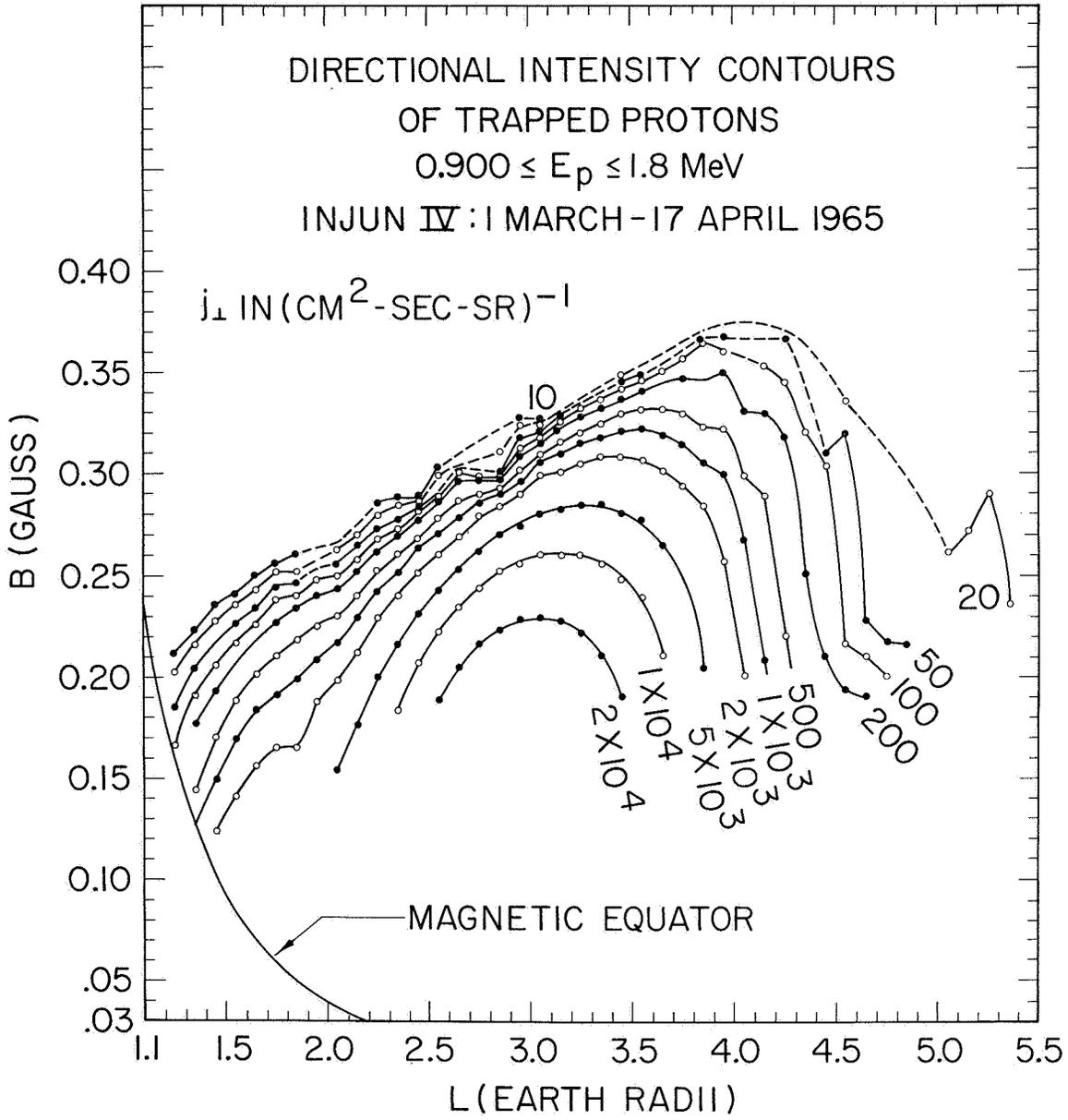


FIGURE 4

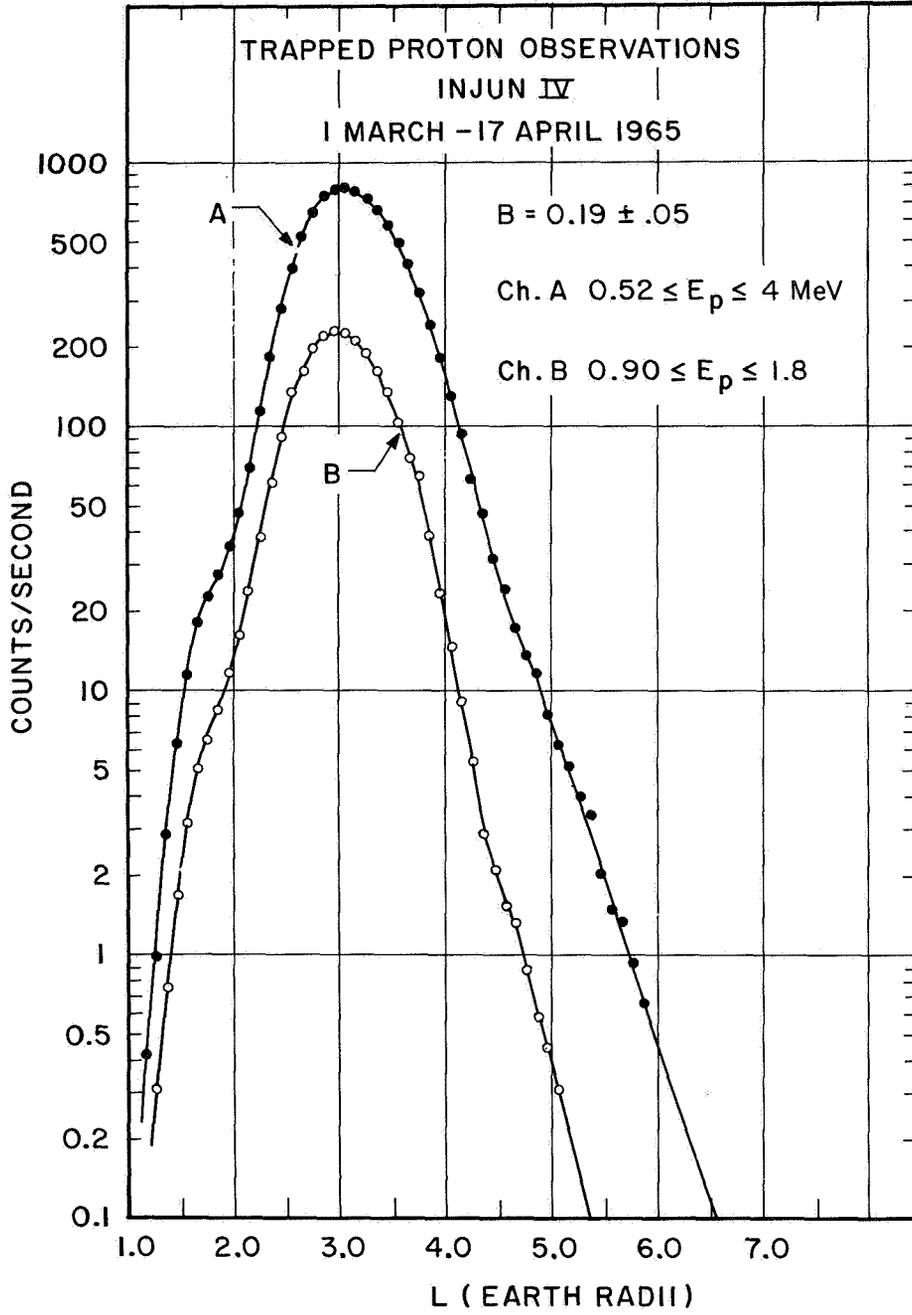


FIGURE 5

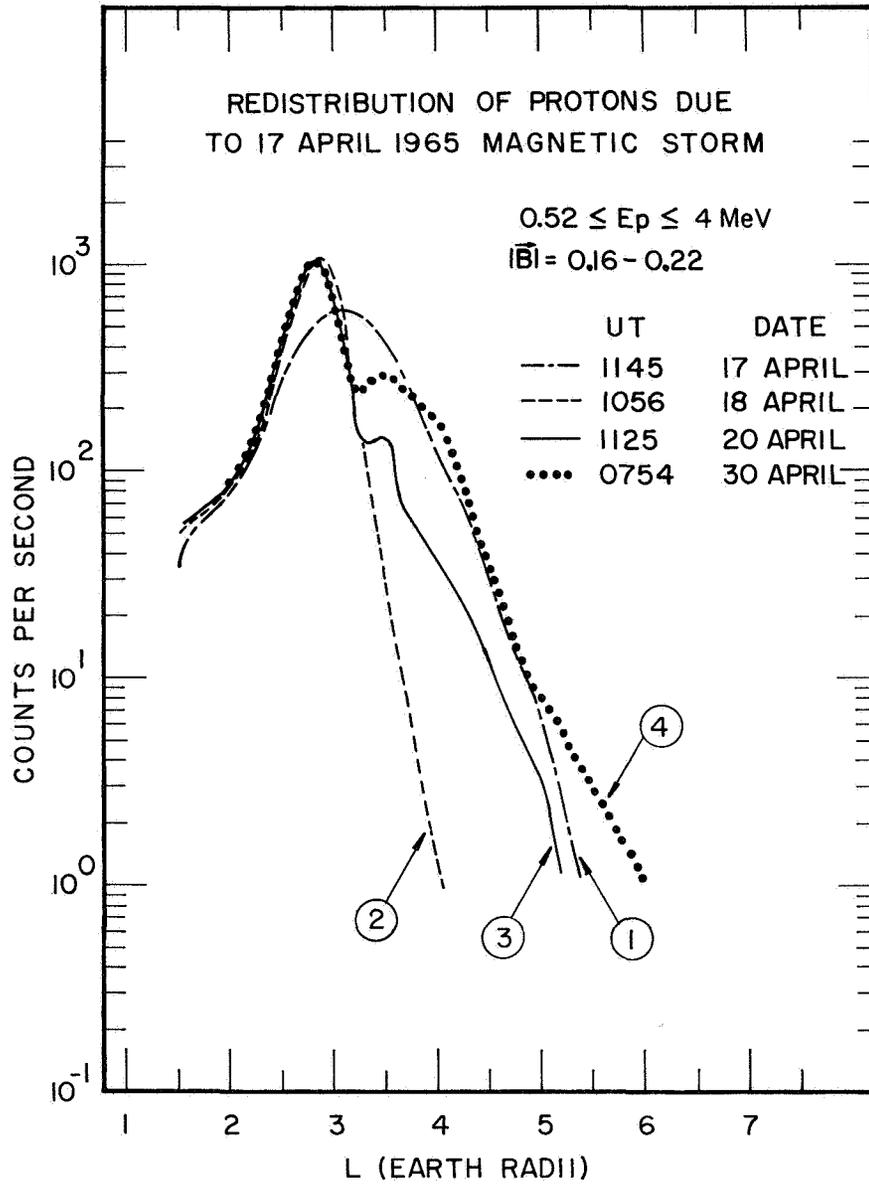


FIGURE 6

SPECTRUM VARIATION WITH L

667-766
(R-0)

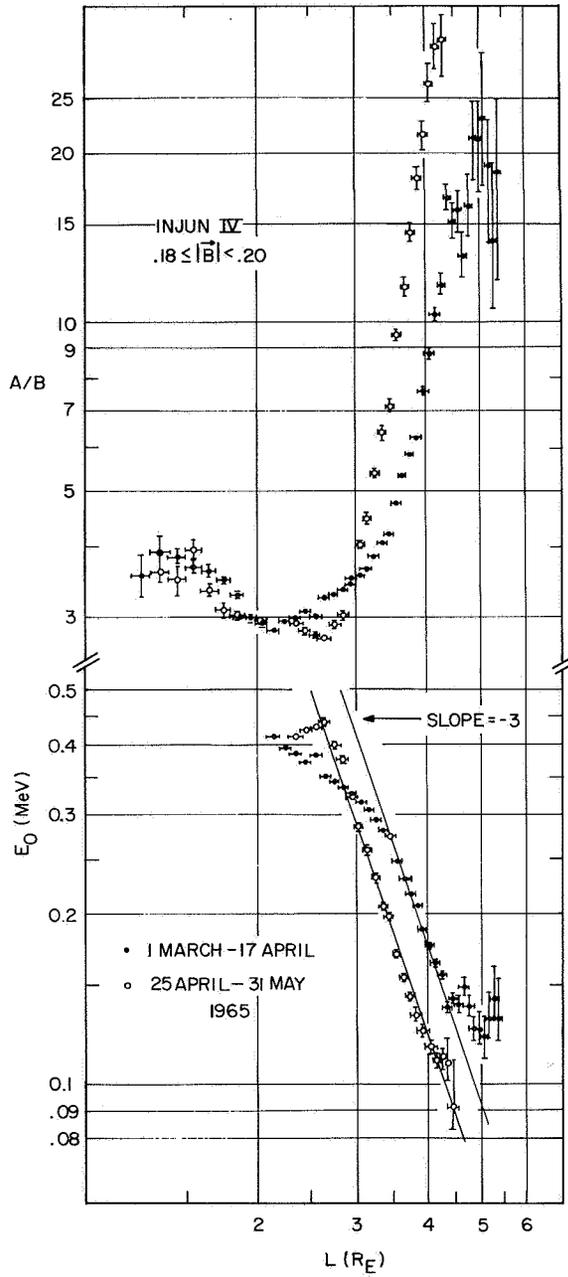


FIGURE 7

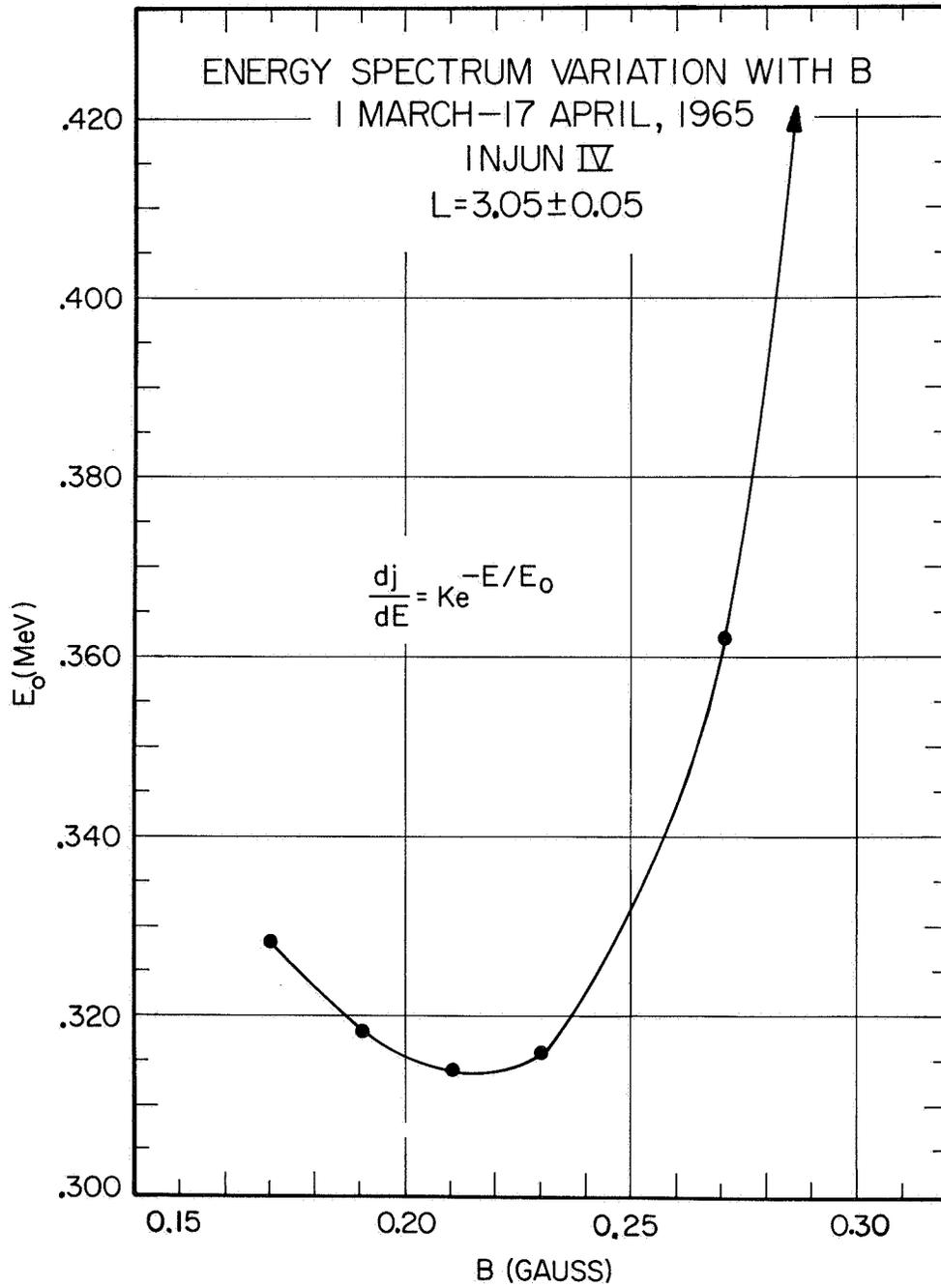


FIGURE 8

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION	
University of Iowa Department of Physics and Astronomy		UNCLASSIFIED	
		2b. GROUP	
3. REPORT TITLE			
Observations of Low Energy (~ 0.5 MeV) Trapped Protons with Injun IV			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
Progress July 1967			
5. AUTHOR(S) (Last name, first name, initial)			
Krimigis, S. M.			
6. REPORT DATE		7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1967		29	14
8a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S)	
Nonr 1509(06)		U. of Iowa 67-51	
b. PROJECT NO.			
c.		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.			
10. AVAILABILITY/LIMITATION NOTICES			
Distribution of this document is unlimited.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY	
		Office of Naval Research	
13. ABSTRACT			
[See page following]			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Trapped Protons Radiation Belts						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.