NOTAS DE FÍSICA

E=mc²

qp-pq=ℏi

Some Results From The IMP-I GM Cosmic Ray Detector

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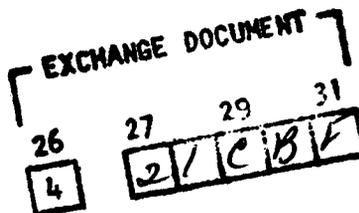and R. A. R. Palmeira

SOME   RESULTS FROM THE IMP-1 GM COSMIC RAY DETECTOR

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SOME RESULTS FROM THE IMP-1 GM COSMIC RAY DETECTOR *

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ABSTRACT:

Results obtained with two mutually perpendicular GM telescopes on board the IMP-1 (Explorer XVIII) satellite are presented. It is shown that these results imply an anisotropic recovery of the cosmic ray intensity towards the maximum of the 11 year variation, the greatest modulation taking place in a direction close to the ecliptic poles. It is also shown that these results are consistent with the current views concerning the cavity that the solar wind produces in the inner solar system when it is slowed down and stopped by the galactic material. The omnidirectional intensity of particles with energy > 40 Mev seems to suffer periodic fluctuations with period close to 12 hours. It is further shown that these fluctuations agree in amplitude and phase with similar fluctuations measured with the Leep River Super Neutron Monitor (the semi-diurnal variation). This suggests the existence of a mechanism capable of producing a true time variation in the cosmic ray intensity as seen by the satellite detector, and this mechanism could also explain the semi-diurnal variation measured with ground detectors. No explanation is offered for such mechanism.

SUM detector. In the same figure we show for comparison the daily average counting rate of a large plastic scintillator used in another cosmic ray experiment on board of the same satellite, and the Deep River Super Neutron Monitor daily averages [1].

Fig. 4 shows the daily average counting rates of the 2 telescopes T_p and T_n. We can see that there is good agreement between the 2 curves in the short and long term charges.

In order to study the long term trend we submitted the data from both telescopes to a 15 day double moving average process in order to eliminate the short term fluctuations. The results are presented in Fig. 5.

We can see from this slide that both telescopes have a trend to increase, following the general trend of the 11 year cycle variation. There is a tendency however for the T_p telescope, which has more directional selectivity, to recover faster than T_n, which looks into a broader area in the sky and can therefore be considered as measuring an averaged background intensity.

In order to check this point more throughly, we plotted the ratio T_p/T_n against time and compared with similar curve for the SUM detector. The results are presented in Fig. 6.

It is clear from this slide that the ratio T_p/T_n follows very closely the SUM curve, indicating that as the cosmic ray intensity recovers following the 11 year cycle variation, the telescope along the spin axis which points close to the

ecliptic poles, sees the greatest change. If we interpret the
11 year solar cycle variation of the cosmic ray intensity as due
to the formation of a cavity in the inner solar system due to
the blowing of the solar wind and its eventual slowing down and
stopping, with the cosmic ray intensity inside this cavity
being less than the galactic intensity that prevails outside,
our observations support then the idea of a cavity lacking
spherical symmetry. Some measurements of the solar corona den-
sity as a function of distance from the sun during the solar
minimum and maximum are presented in Fig. 7. It is
evident from these measurements that it is the polar corona
that suffers the greatest change during the solar cycle. This
fact is also brought about by direct photographs taken at times
of total solar eclipses. This asymmetry in the visible solar
corona should then also be present in the quiet day coronal
expansion (the solar wind) and in the shape of the cavity that
the solar wind produces when it blows away from the sun until
it is stopped by the galactic environment. Such an asymmetric
cavity as pictured by Ahluwalia and Escobar [2] during solar
minimum is shown in Fig. 8. Taking the equatorial radius of
this cavity to be 50 A.U., it is clear that at the position
of the earth we are closer to the cavity boundary when looking
at large angles from the ecliptic plane. Therefore, since the
coronal changes during the solar cycle are more pronounced
along this direction, we would expect the cosmic ray modulation
to be larger in this direction, and this is what we indeed
observe.

Another feature of the data I would like to discuss is the existence of periodic fluctuations in intensity. Fig. 9 shows the counting rate of the SUM during a few days after launch. We can see from this slide that there are some periodic fluctuations in intensity with period somewhat between 10 and 20 hours, and lasting for several periods.

In order to test whether these fluctuations are a more or less regular feature and to try to determine more accurately their periods, we submitted the data to a power spectrum analysis, the results of which are shown in Fig. 10. We can see that the power is maximum for a period close to 12 hours.

Since this period agrees with the period of the semidiurnal component of the variation measured with ground detectors, we decided to subject the data from the SUM detector and from the Deep River Super Neutron Monitor to a Fourier Analysis. For this purpose we divided the data, starting on Nov. 29, 1963 into 4 groups of 30 days each, and for each group we calculated the amplitude and time of maximum of the 24 and 12 hours waves. The results are presented in Fig. 11. It is clear from this slide that whenever the amplitude of the 12 hours wave is statistically different from zero, the time of maximum is between 0615 and 0715 UT. This holds true for the IMP and Deep River data. The averaged results for the whole period under study are also presented in this slide. They agree remarkably well in amplitude and phase.
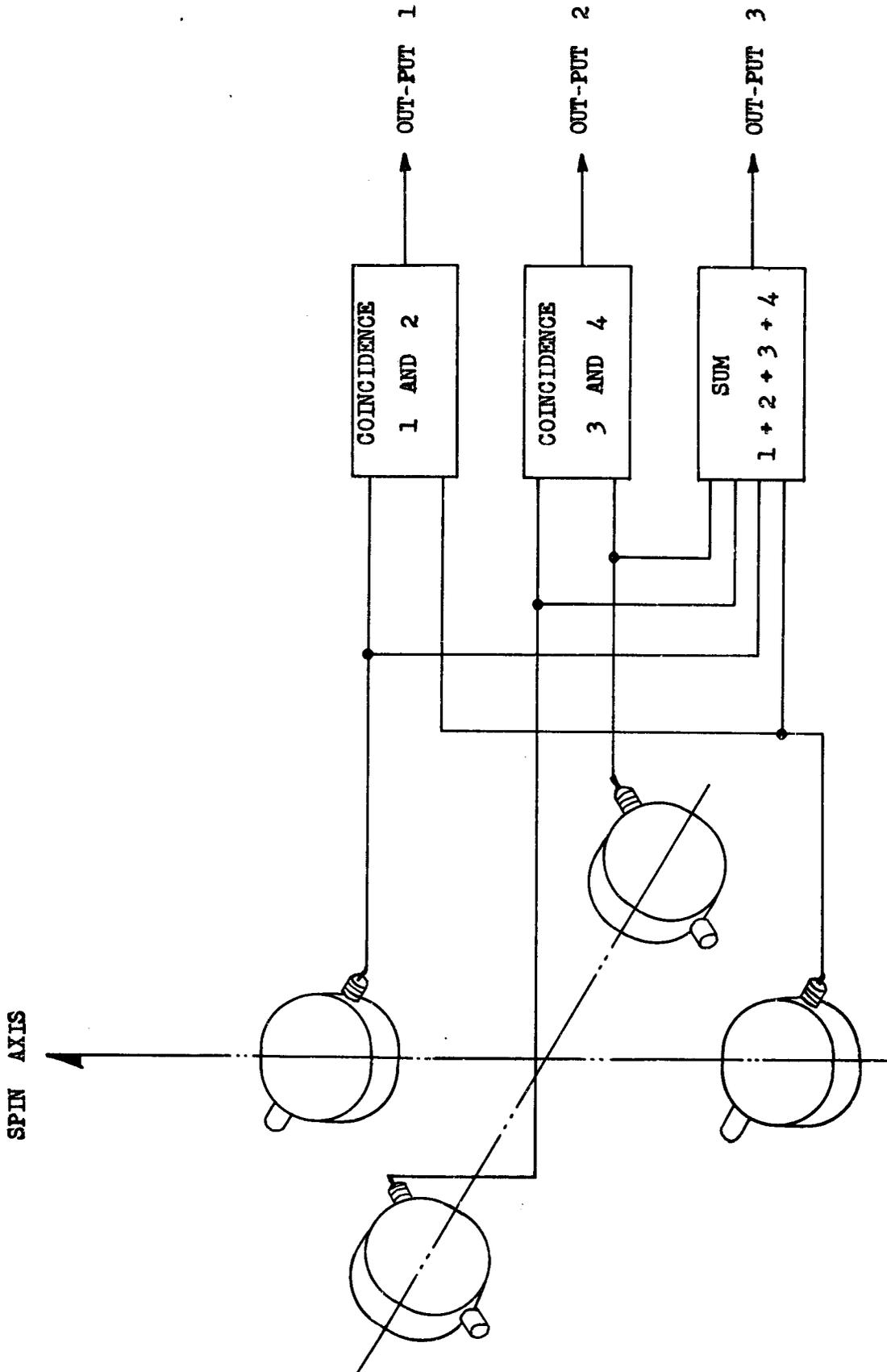
For comparison, we have also included the results of the Fourier analysis of the 24 hours wave. From this we can see that whereas the Deep River data show the usual diurnal variation, with time of maximum close to 2000 UT (1500LT), the IMP data show no statistically significant amplitude for each of the 4 periods considered. This also holds true for the average for the whole period.

Our data suggest then that there exists at some times a periodic fluctuation with period close to 12 hours, in the cosmic ray intensity of particles with energy greater than 40 MeV, and that this fluctuation is a true time variation phenomenon, since no other cause will explain its observation with the satellite borne detector. The fact that a similar fluctuation, for the same period of time was also observed with the Deep River Monitor indicates that such fluctuations extend into the BeV range of energies with a flat spectrum.

No explanation is offered for the origin of such variations, but the agreement with Deep River in amplitude and phase suggests that part or all of the semi-diurnal variation measured with ground detectors might be a true time variation and not a higher harmonic of the diurnal variation, or a variation of meteorological origin.

INTERVAL	I & P				DEEP RIVER NEUTRON MONITOR			
	24 HOUR		12 HOUR		24 HOUR		12 HOUR	
	R (s)	T (UT)	R (s)	T (UT)	R (s)	T (UT)	R (s)	T (UT)
NOV 29 - DEC 28, 1963	0.02±0.03	1251±0432	0.08±0.03	0709±0043	0.26±0.01	1956±0008	0.07±0.01	0716±0015
DEC 29 - JAN 27, 1963-64	0.01±0.03	1816±0701	0.01±0.03	0259±0507	0.30±0.01	2044±0007	0.08±0.01	0557±0012
JAN 28 - FEB 26, 1964	0.03±0.03	1943±0494	0.09±0.03	0712±0096	0.37±0.01	1985±0005	0.10±0.01	0651±0010
FEB 27 - MAR 27, 1964	0.04±0.03	0809±0309	0.12±0.03	0657±0024	0.38±0.01	2034±0005	0.08±0.01	0641±0010
NOV 29 - APR 6, 1963-64	0.02±0.01	1056±0312	0.07±0.01	0644±0021	0.33±0.005	2012±0003	0.08±0.005	0636±0005

AMPLITUDE AND TIME OF MAXIMUM OF 24 AND 12 HOUR WAVES

OUT-PUT 1

OUT-PUT 2

OUT-PUT 3

COINCIDENCE
1 AND 2

COINCIDENCE
3 AND 4

SUM
1 + 2 + 3 + 4

SPIN AXIS

IMP GEIGER COUNTER TELESCOPE

FIG. 1

NORTH ECLIPTIC POLE
⊕

ECLIPTIC

+45

DECLINATION

0

-45

⊕
SOUTH ECLIPTIC POLE

90   180   270

R I G H T   A S C E N S I O N

"LOOK" DIRECTION OF
TELESCOPE   ALONG
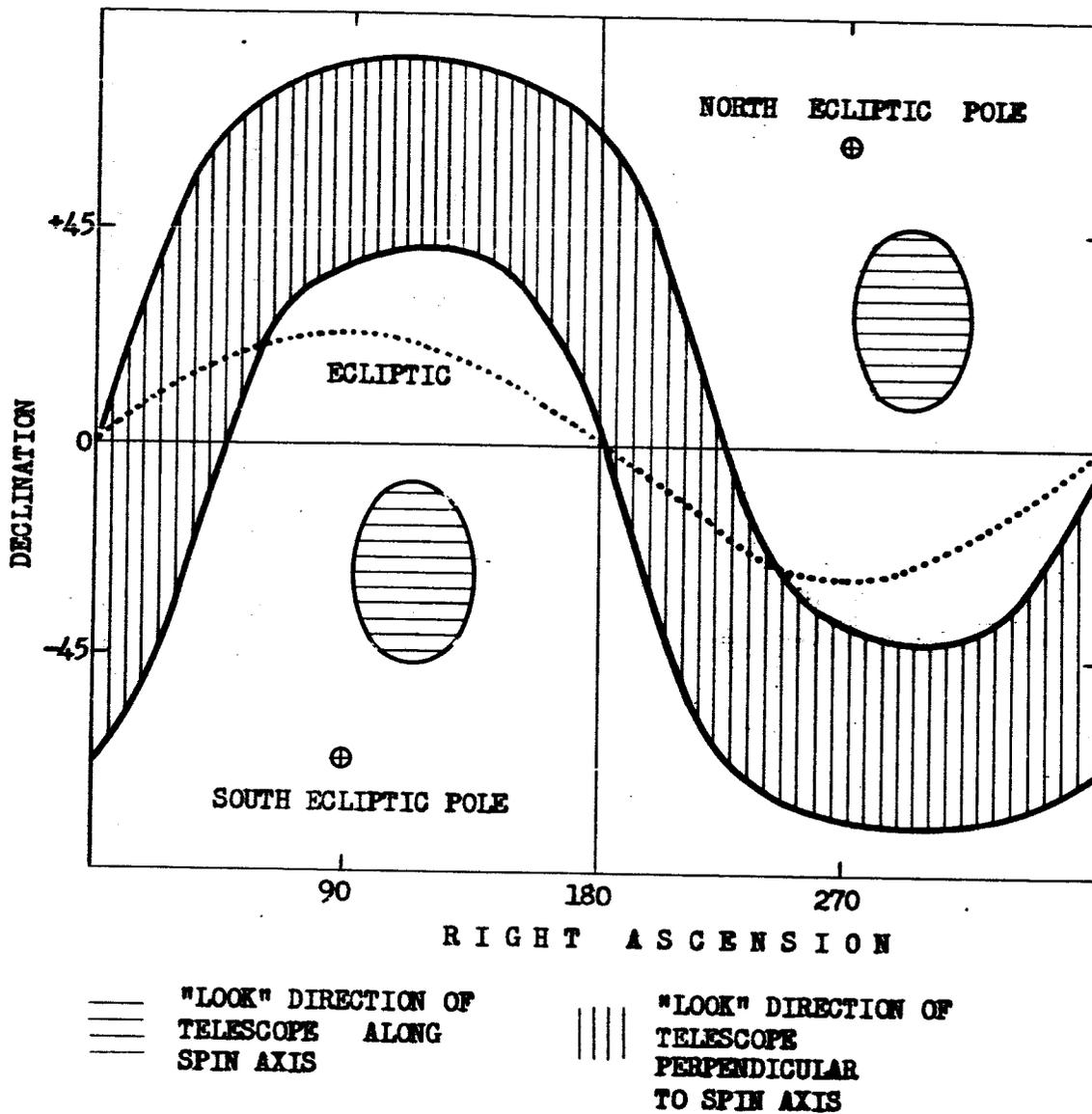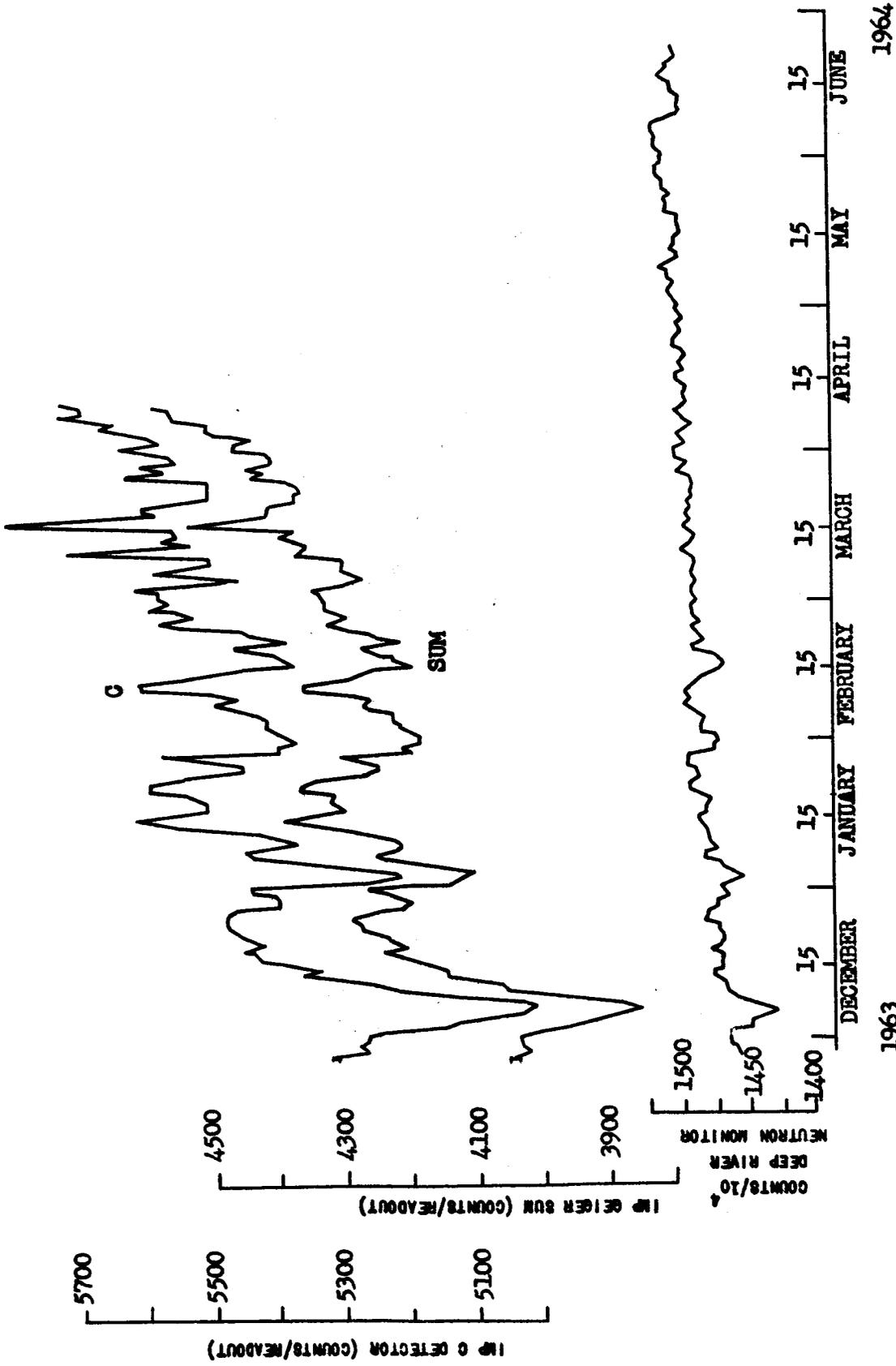SPIN AXIS

"LOOK" DIRECTION OF
TELESCOPE
PERPENDICULAR
TO SPIN AXIS

FIG. 2

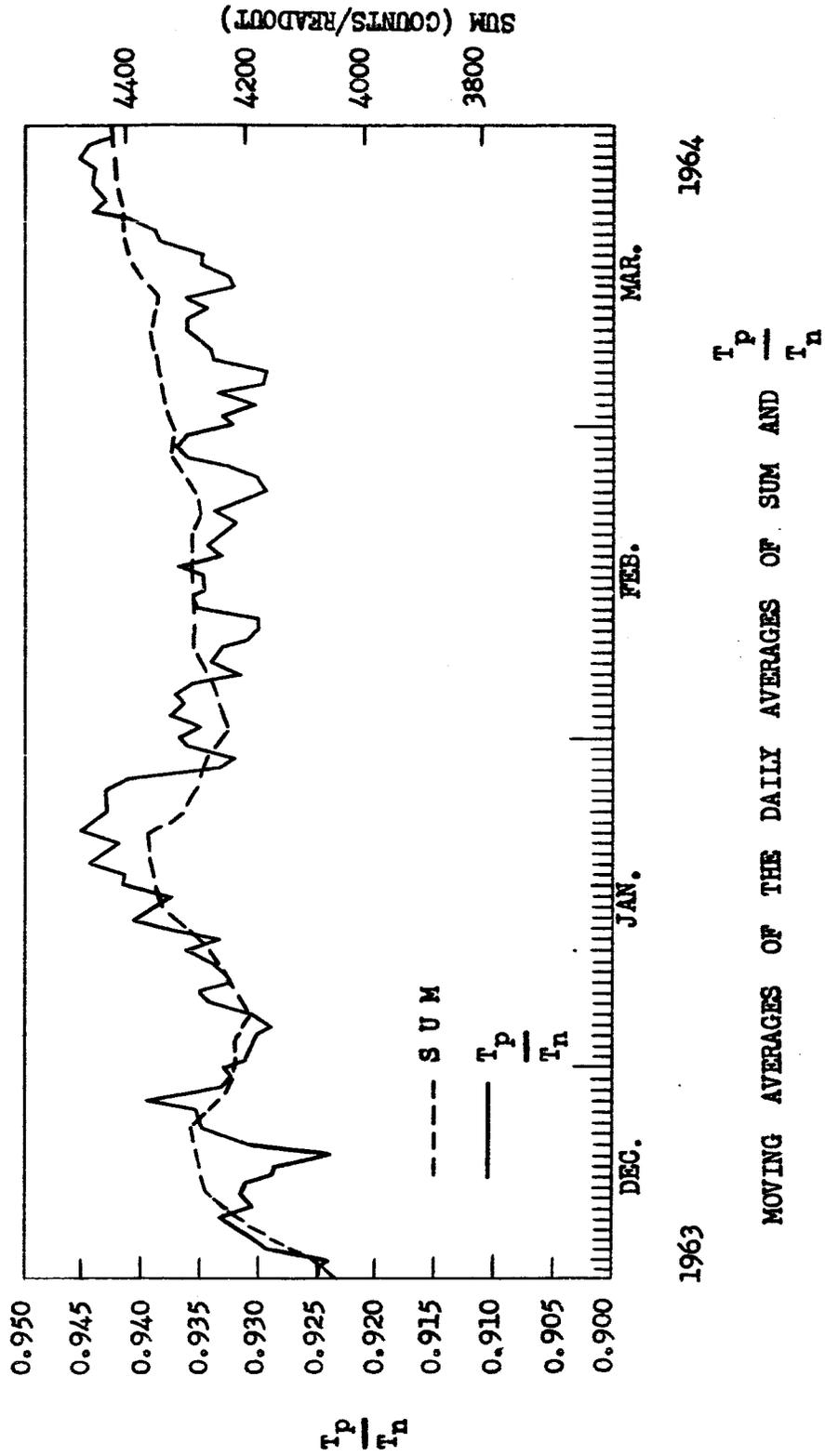DAILY AVERAGES OF THE SUM, THE C DETECTOR AND DEEP RIVER NEUTRON MONITOR

FIG. 3
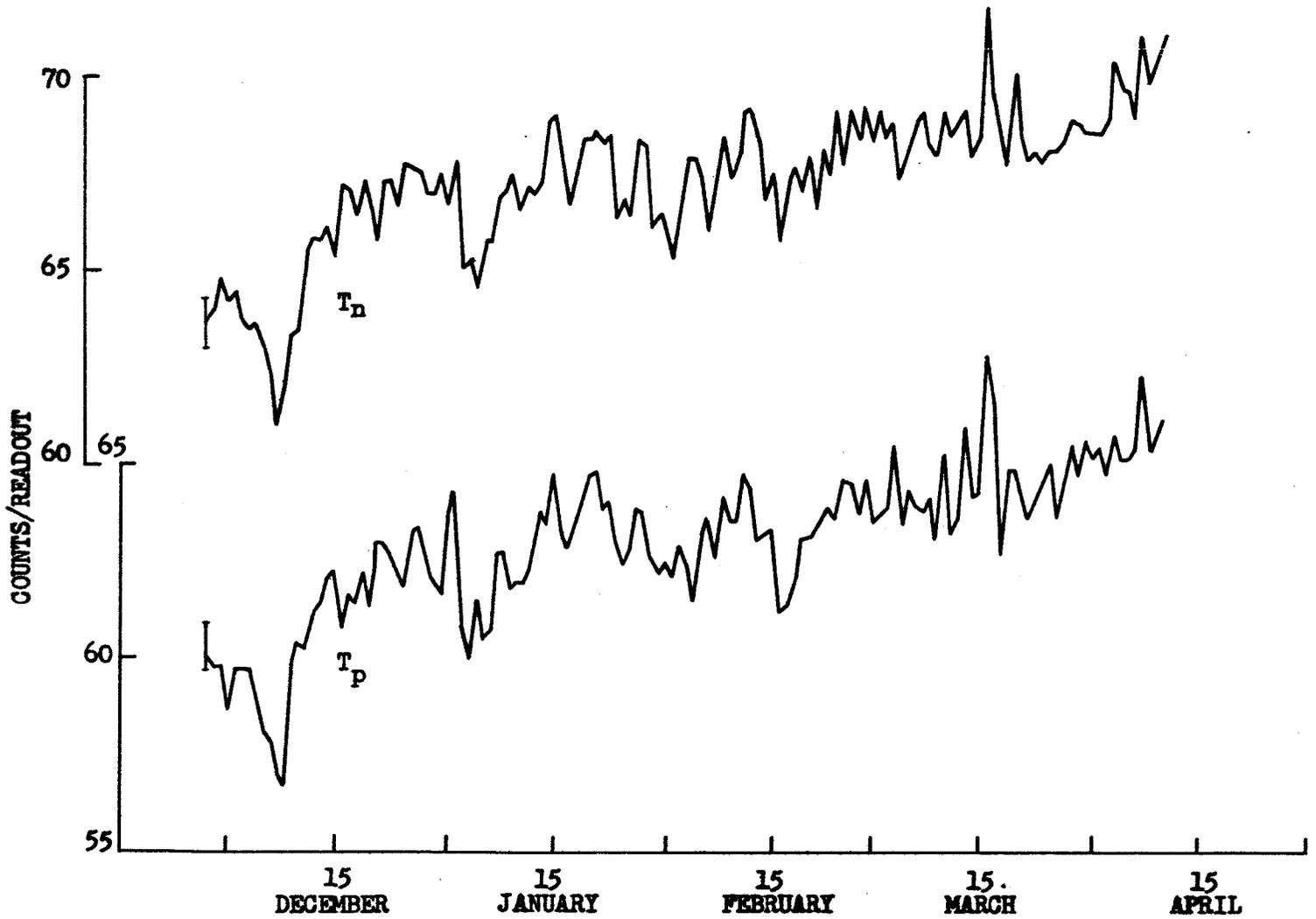
DAILY AVERAGES OF THE PARALLEL (T_p) AND PERPENDICULAR (T_n) TELESCOPES

FIG. 4

228
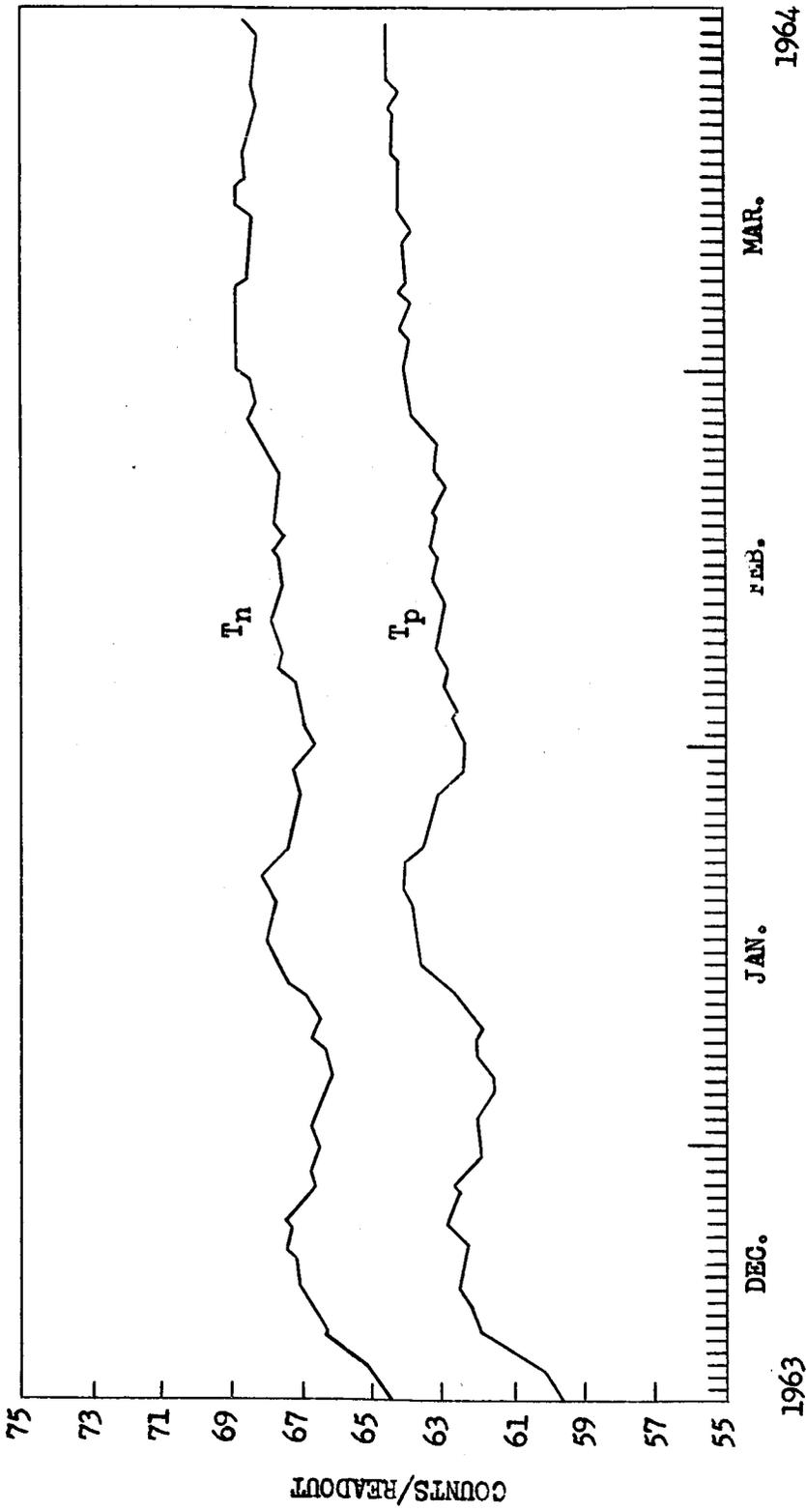
MOVING AVERAGES OF T_p AND T_n

FIG. 5

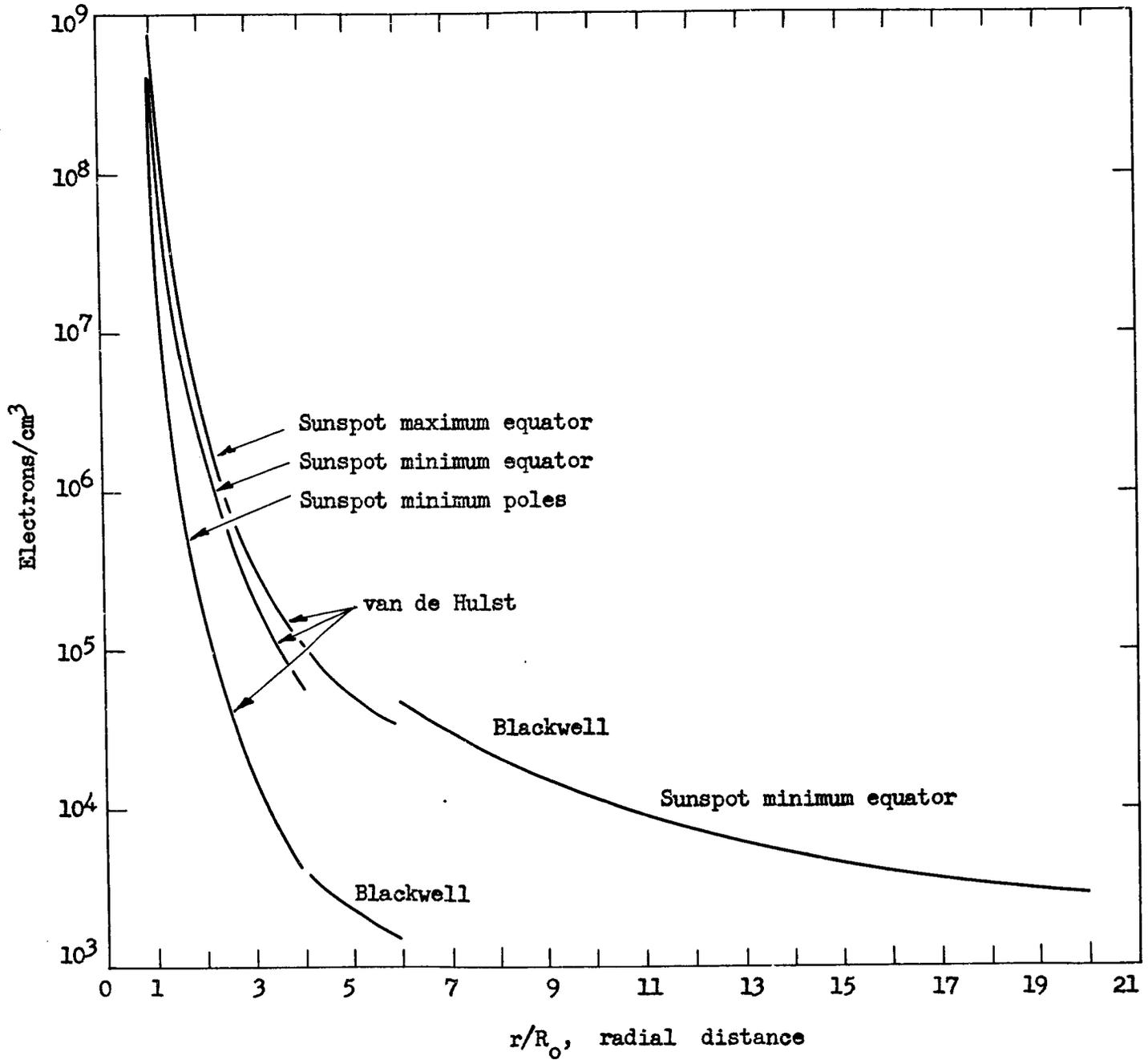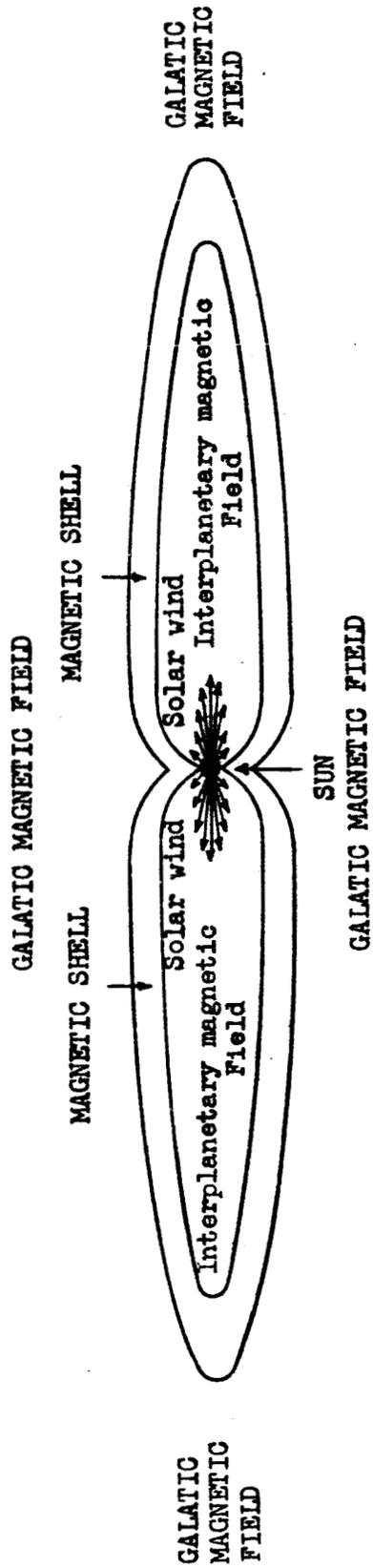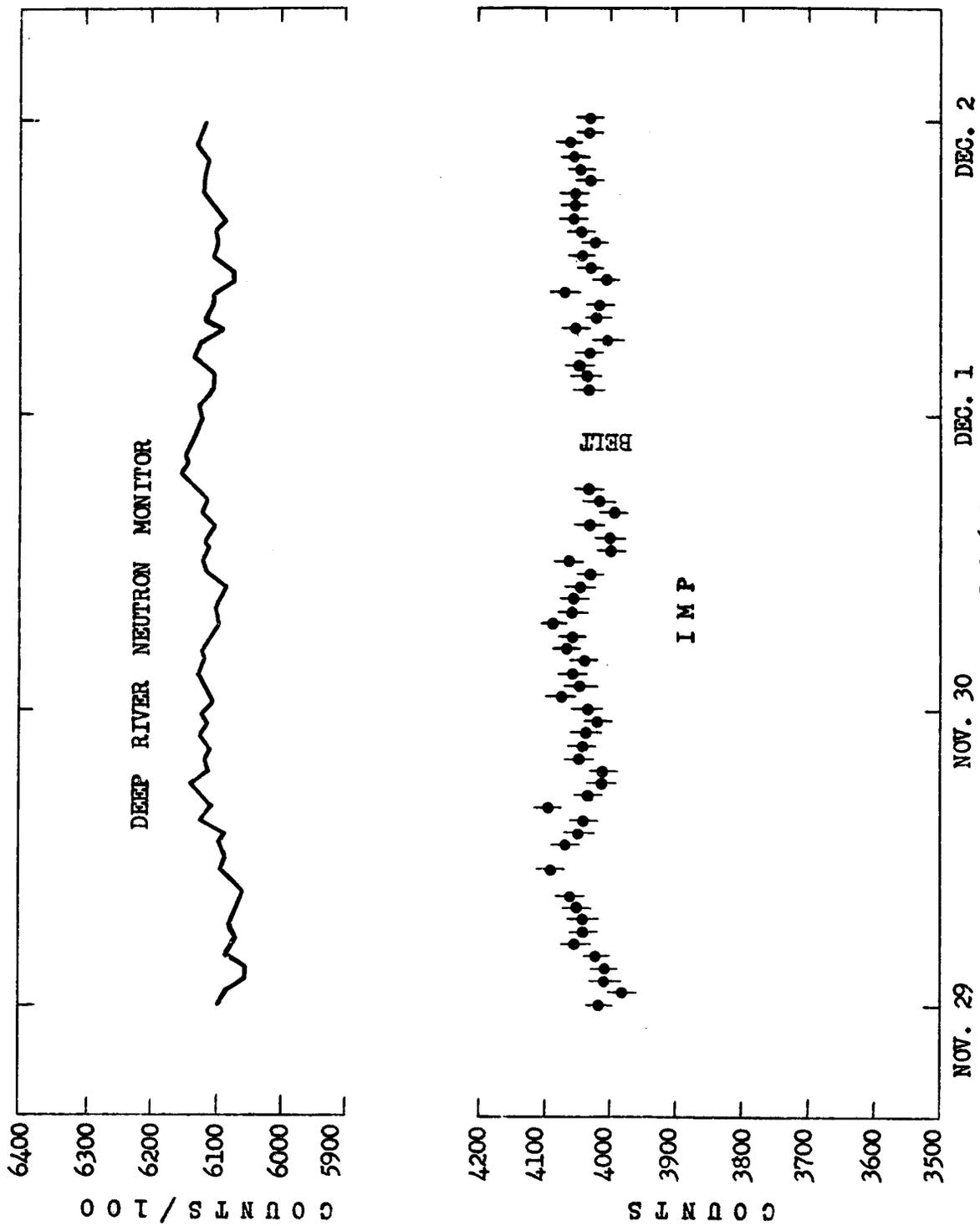MOVING AVERAGES OF THE DAILY AVERAGES OF SUM AND $\frac{T_p}{T_n}$

FIG. 6

FIG. 7

GALATIC MAGNETIC FIELD

MAGNETIC SHELL

MAGNETIC SHELL

Solar wind
Interplanetary magnetic
Field

Solar wind
Interplanetary magnetic
Field

GALATIC
MAGNETIC
FIELD

SUN

GALATIC MAGNETIC FIELD

GALATIC
MAGNETIC
FIELD

SHAPE OF SOLAR CAVITY NEAR SOLAR MINIMUM

FIG. 8

DEEP RIVER NEUTRON MONITOR

COUNTS/100

6400
6300
6200
6100
6000
5900

IMP

BELT

COUNTS

4200
4100
4000
3900
3800
3700
3600
3500

NOV. 29   NOV. 30   DEC. 1   DEC. 2

1 9 6 3

FIG. 9

FIG. 10