netic moment of 2.74 and the spin of 7/2, with the theory of Inglis,[8] indicate that the orbital and spin vectors of the odd proton in the nucleus are opposed, $I=l-\frac{1}{2}$. Thus, the nuclear orbital momentum, l, equals four.

We wish to acknowledge the help of Mr. George Parker and Mr. Gordon Hebert, of the Chemistry Division, Oak Ridge National Laboratory, who isolated the I^{129} from fission material.

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*** The sign of the magnetic moment is not obtained directly from the experiment because the Zeeman patterns are symmetrical. However, since the I^{129} nucleus has an odd number of protons and an even number of neutrons, a positive sign for μ is reasonable in view of the large spin value and the large magnitude of μ.

**** After this note was written, Dr. C. K. Jen informed us by private communication that he has measured the nuclear magnetic moment of S^{33} with the microwave method.

† This effect is analogous to the Paschen-Back effect in atomic fine structure and to the Back-Goudsmit effect in atomic hyperfine structure.

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Latitude Dependence at 30,000 Feet of Penetrating Particles Slowed Down After Traversing 15 cm of Lead*

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IN two recent B-29 expeditions from China Lake (California) to Lima, Peru, and to Fairbanks, Alaska, experiments have been carried out to investigate the composition of ionizing cosmic rays slowed down after traversing a certain thickness of lead. Mesons were separated from other ionizing particles with the counter arrangement sketched in the left side of Fig. 1. Counters A_1, A_2 (A_2 being two counters in parallel), and A_3 were in coincidence with counters B_1 plus B_2 (two in parallel), B_2 and B_2 plus B_3,

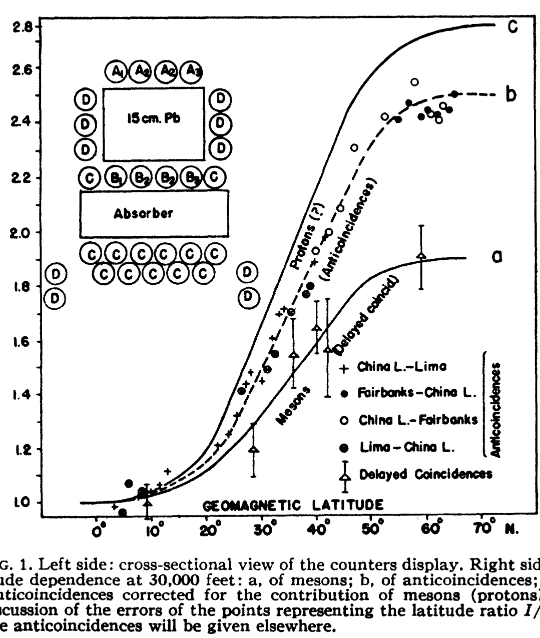

FIG. 1. Left side: cross-sectional view of the counters display. Right side: latitude dependence at 30,000 feet: a, of mesons; b, of anticoincidences; c, of anticoincidences corrected for the contribution of mesons (protons?). A discussion of the errors of the points representing the latitude ratio I/I_0 of the anticoincidences will be given elsewhere.

TABLE I. Results of measurements of delayed coincidences with graphite absorber at 30,000 feet at several latitudes. Mesons observed belong to the momentum range 315 to 348 Mev/C.

Average geomagnetic latitude (North)		9.0°N	28.5°	35.5°	40.0°	42.0°	59.0°
Duration of observation (minutes)	(Δt)	350	298	220	290	142	220
Delayed coincidences per hour due to mesons disintegrating in the time interval	1.14 to 3.94 μsec.	27.5 ±2.4	32.0 ±3.2	38.5 ±3.5	42.8 ±4.5	*	50.7 ±5.0
	2.12 to 4.92 μsec.	17.4 ±1.7	17.6 ±1.9	26.6 ±2.7	28.1 ±2.4	24.2 ±3.2	33.3 ±3.0
	3.10 to 5.90 μsec.	10.4 ±1.3	11.6 ±1.5	*	17.2 ±1.9	16.1 ±2.5	18.3 ±2.2
	4.08 to 6.88 μsec.	6.5 ±1.05	6.45 ±1.25	*	11.6 ±1.55	10.5 ±2.1	13.4 ±1.9
Extrapolated delayed coincid. per hour	(N)	46.5 ±2.7	53.5 ±4.4	72.0 ±6.0	76.9 ±4.5	73.2 ±8.6	89.1 ±5.2
Latitude ratio	(I/I_0)	1.00 ±0.06	1.14 ±0.095	1.55 ±0.13	1.65 ±0.095	1.57 ±0.185	1.91 ±0.11

* Not recorded.

respectively. All these double coincidences, added by means of a mixer, will be indicated as (AB). A 10-cm thick block of graphite surrounded by a group of counters, C, was placed below counters B and used as an absorber for the particles coming within the solid angle corresponding to the coincidences (AB). Counters C covered this solid angle. They were at the same time in "delayed coincidence" and in "anticoincidence" with respect to the coincidences (AB), while counters D were only used as additional anticoincidence counters. The delayed coincidences were registered by four "channels" of the same "time width" $\Delta\theta$ (2.8 μsec.), so that four points of the decay curve of mesons slowed down in the absorber were obtained simultaneously. The minimum delay for which a delayed coincidence was registered in the first channel was 1.14 μsec. The time distance between each channel and the next one was 0.98 μsec. For the apparatus employed, spurious delayed coincidences could practically occur only for random events in which an anticoincidence $(AB-C)$ was followed after a short time by a single discharge (C) of counters C.*** Examples of decay curves obtained at altitude have been shown in a previous paper.[1]

By extrapolation of the decay curve to the zero time, one obtains the number, N, of mesons stopped per unit time in the absorber and which disintegrate between 0 and $\Delta\theta$ into electrons striking counters C. If p is the average value of the probability for the decay electrons of mesons, stopped in the absorber, to strike counters C, the number, M, of mesons stopped in the absorber after traversing the counter telescope is

$$M=N/p(1-\exp(-\Delta\theta/\tau)). \tag{1}$$

Events were registered as anticoincidences when no anticoincidence counter fired within 1.1 μsec. before or 7.8 μsec. after the arrival of a particle producing a coincidence (AB). Since the probability for an ordinary meson to disintegrate more than 7.8 μsec. after it has been stopped is less than 3 percent, the intensity, I_a, of the "true anticoincidences" (difference between the anticoincidences registered with and without absorber) is

$$I_a=(1-p)M+X, \tag{2}$$

where X represents the contribution due to particles which did not give rise, within 7.8 μsec. after they had been stopped in the absorber, to emission of secondary ionizing particles striking counters C.

In order to obtain the value of p, measurements with and without graphite absorber have been performed in Chicago, before and after the flights, with supplementary 5 cm and 20 cm of lead above counters A. From the results of these measurements the same value, 0.29±0.015, is obtained in both cases for p, through Eqs. (1) and (2), if X is assumed to be negligible in these conditions.

The results concerning the latitude dependence of the delayed coincidences registered at 30,000 feet with absorber are summarized in Table I. The last line of the table contains the ratio ("latitude ratio," I/I_0) between the value of N obtained at each latitude and near the equator (9° North). Curve a in Fig. 1 represents these data. The results concerning the anticoincidences are graphically represented in the same way (namely, as latitude ratio I/I_0) by the points of curve b, curve c, which represents the latitude dependence of the X component, is obtained, through Eqs. (1) and (2), from the other two curves. If the X particles were protons, they should have a momentum of about 1 Bev/c to penetrate the 15 cm Pb interposed between counters A and B. A latitude ratio of 2.8 between the highest latitude and the equator for protons of such a momentum seems to be reasonable if compared with the latitude dependence recently observed for "stars"[2] and for small "bursts."[3] Further arguments which support the view that the X component is made up essentially of protons will be given in a future paper.

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** On leave from the University of Rome, Italy.
*** A small correction for the spurious delayed coincidences produced in the first channel by the spontaneous lags of counters C has been introduced on the basis of measurements taken in flight without absorber. A detailed account of all corrections introduced will be given in a complete report of this research.

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Electron Gun Emission and X-Ray Output for Three Betatrons

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IN a recent publication[1] a new theory was presented for the process of capture of electrons in the betatron. In an attempt to check this theory, measurements were made on three different betatrons of x-ray output *versus* electron emission from the gun. The results are interesting because of the great differences between curves plotted for different machines and because of the change of the shape of the curves with gun voltage. In one respect all the curves confirm qualitatively an important point of the theory namely for the greater portion of the curves the x-ray output varies as the gun electron emission current to a power larger than one.

All x-ray measurements were referred to Victoreen thimbles in one-eighth inch lead jackets and special checks were made on the location of the x-ray beam by means of films at different distances in order to exclude errors from stray electrons. The direct readings were taken on x-ray ionization chamber monitors calibrated with the Victoreen instrument.

In all three machines the magnetic field varies inversely proportional to the three-quarters power of the radius over most of the region between gun and target.

The curves shown at the left in Fig. 1 were taken on the 100-Mev betatron[2] which operates at 60 cycles per second and has a pumped vacuum tube. The orbit diameter is 66 inches, the free vacuum space is 3.4 inches high by 4.6 inches wide, corresponding respectively to relative apertures of 0.052 and 0.07. An improved electron gun with a barium aluminate cathode was used. During its long life of more than one thousand hours the x-ray output had dropped from 2300 roentgens per minute at 1 meter to the present figures principally on account of reduced spark over potential. The voltage pulse is a half-sine wave of 10 microsecond duration.

The curves in the middle of Fig. 1 were taken on the 50-Mev biased betatron[3] operating at 180 cycles per second with a sealed off vacuum tube. The orbit diameter is 23 inches, the free vacuum space is 1.63 in.×2.21 in. corresponding to relative apertures of 0.071 and 0.096 respectively. The gun has an improved focusing cup with a conventional coiled tungsten filament and a fourth electrode of adjustable potential which permits directional adjustment of the beam. The voltage pulse wave form is very nearly a half-sine wave of 5 microsecond base width.

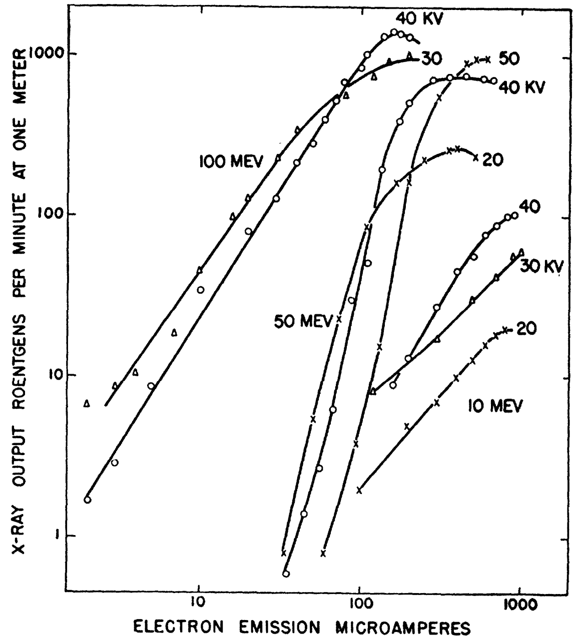

FIG. 1. Logarithmic plot of x-ray output *versus* electron gun emission for a 100-Mev, a 50-Mev and a 10-Mev betatron, at different gun voltages ranging from 20 to 50 kilovolts.

On the right in Fig. 1 are shown the data obtained with an industrial 10-Mev betatron operating at 1920 cycles per second. The orbit diameter is 10.5 in.; the free vacuum space is 1.7 in. ×2.33 in. with consequent relative apertures of 0.16 and 0.22. The tube is sealed off and has an electron gun like the one in the 50-Mev biased betatron. The gun voltage pulse has a waveform with a base of 6 microseconds and a flat top of 2 microseconds.

The steepest slopes of the curves as drawn are in descending order of gun voltage for the 100-Mev machine 1.6 and 1.45, for the 50-Mev machine 5.7, 5.0, and 4.3, and for the 10-Mev machine 1.7, 1.1, and 1.2. For all three machines the maximum x-ray output obtainable with excess emission available at a given gun voltage varies very nearly as the 1.25 power of the gun voltage.

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The Superconducting Torus

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A RECENT exact solution of the electrodynamic behavior of a superconducting torus by one of the authors,[1] presents the opportunity of discussing the effect of changes in torus dimensions on the hysteresis loop obtained by magnetic cycling.

Figure 1 is the hysteresis loop to be expected for a superconducting torus with s, the ratio of mean radius of toroidal ring to radius of toroidal wire, equal to four. Shoenberg[2] in studying the properties of a superconducting torus used a torus for which $s=4$. Within experimental error his results are in agreement with Fig. 1.