cm^2 per air nucleus. This is in rough agreement with the experimental results on mesotron production in paraffin.[3]

The normalization also determines the number of protons in the energy range 6 to 16 which produce mesotrons. Table II gives the ratio of these protons to the hard component at sea level.

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[1] J. Hamilton, W. Heitler, and H. W. Peng, Phys. Rev. **64**, 78 (1943).
[2] P. S. Gill, M. Schein, and V. Yngve, Phys. Rev. **72**, 733 (1947).
[3] M. Schein and D. J. Montgomery, *Problems in Cosmic Ray Physics* (Princeton University Press, Princeton, New Jersey, 1946).

On the Generation in Paraffin of Ionizing Penetrating Particles by a Neutral Component of the Cosmic Radiation

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De Vos and du Toit[1] have recently found at sea level, with the counter-set drawn in Section *a* of Fig. 1, a ratio $R=1.03$ between the threefold coincidences $A+B+C$, recorded with a paraffin layer 1.3 cm thick in π, and the ones recorded with the same layer in π'. In their opinion the effect is outside the experimental uncertainty, and the increase in the frequencies when paraffin is in π is due to the generation in the paraffin layer of mesons or protons by some neutral component of the cosmic radiation.

This result is very interesting, because experiments[1,2] like the above-mentioned, performed at sea level also, but with layers of lead instead of paraffin, did not show the same effect; therefore one is compelled to think of a particular phenomenon characteristic of the low atomic number materials.

In order to look into this point the following experiments were performed:

Series 1: (see Section *b* Fig. 1) with the telescope $ABCD$ arranged under a thin deck (0.5-cm wood), the fourfold coincidences $A+B+C+D$ were recorded with 2 cm of paraffin alternatively in π and in π'. (Counter surface: 4×40 cm^2, counter walls: 1-mm brass, resolving time of the recording apparatus: 2.10^{-5} sec.) The penetrating particles were selected by 12.5-cm Pb and the side showers stopped by 5-cm Pb around the counters D.

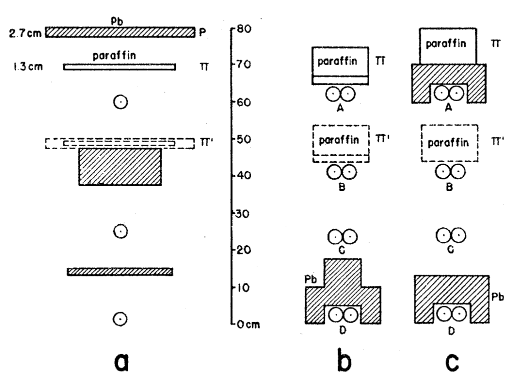

FIG. 1.

As the Table (series 1) shows, no changes in frequencies were recorded by changing the position of the paraffin.

TABLE I. Measurements on the generation of ionizing particles by a neutral component of cosmic rays.

Series	Lead coinc.	Lead min.	Lead coinc./min.	Paraffin coinc.	Paraffin min.	Paraffin coinc./min.	Ratio R
1	69,172	7836	8.827 ±0.034	61,016	6922	8.815 ±0.036	1.0013 ±0.0080
2	43,205	4940	8.746 ±0.042	45,792	5358	8.546 ±0.040	1.023 ±0.010
3	71,394	8225	8.680 ±0.033	68,708	7881	8.718 ±0.034	0.995 ±0.008
4	61,655	7784	7.922 ±0.033	66,219	8338	7.942 ±0.031	0.997 ±0.008

Series 2: counters and screens as in series 1, but paraffin layer: 10 cm.

As it appears in the Table (series 2), a ratio $R=1.02\pm 0.01$ was found in this case.

Series 3: with the arrangement drawn in Section *c* of Fig. 1, we tried to test whether or not the result of series 2 was a real effect, or a spurious one caused by soft secondary particles generated in the paraffin while in π; such particles could give rise to spurious coincidences in association with penetrating particles hitting only counters B, C, and D. This possibility was removed by arranging a screen of lead 5 cm thick around the counters A (paraffin layer: 10 cm).

As the Table (series 3) shows, in this case we found $R=1$ within the experimental uncertainty, which indicates that the positive result of series 2 was really caused by such a spurious effect.

Series 4: In order to make our data more comparable with De Vos and du Toit's result, we performed a last experiment arranging above the counter-set used in series 3 a layer of 2.5-cm Pb, like that (2.7 cm) placed above the counter-set in De Vos and du Toit's experiment (see Fig. 1a).

In this case also no changes in frequencies were recorded when the position of the paraffin was changed (see Table: series 4).

We think our experimental arrangements (series 3 and 4) afford the following advantages with regard to De Vos and du Toit's experiment: (a) screening against side showers (Pb screens surrounding D and A); (b) removal of soft secondary particles generated in the materials above the telescope (Pb screen surrounding A and shapes of paraffin layers so chosen to cover only the solid angle of the telescope); (c) large efficient surface of the telescope and therefore short recording times (our frequencies were about 17 times larger than De Vos and du Toit's); and (d) statistical errors in every series about one-half the error in the result of the above-mentioned observers.

The results obtained compel us to point out that our experiments do not confirm the effect found by De Vos and du Toit, both for thin and thick paraffin layers. Therefore we reach the conclusion that, at sea level, the phenomena of generation in paraffin of penetrating ionizing particles by neutral radiation are not detectable, or, in any case, their amount is less than ~1 percent.

A fuller discussion of these experiments will be found elsewhere.[3]

We wish to emphasize that our negative conclusion about generation in paraffin of penetrating particles by neutral radiation refers only to experiments performed at sea level. In higher stations, the generation of penetrating particles in low atomic number materials seems to have been found by several experimenters.[4]

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[1] P. J. G. De Vos and S. J. du Toit, Phys. Rev. **70**, 229 (1946).
[2] Rossi, Janossy, Rochester, and Bound, Phys. Rev. **58**, 761 (1940).
[3] C. Milone and V. Tongiorgi, Nuovo Cimento, in press.
[4] D. K. Froman and J. C. Stearn, Phys. Rev. **54**, 969 (1938); M. Schein, M. Jona, and J. Tabin, Phys. Rev. **64**, 253 (1943); O. Salo and G. Wataghin, Phys. Rev. **67**, 55 (1945).

Energy Levels of O^{17} Obtained from $O^{16}(d, p)O^{17}$ and $N^{14}(\alpha, p)O^{17}$

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The measurement of nuclear energy change (Q) values in transmutation experiments enables the positions of deep nuclear levels to be observed. These levels are not yet explained and there is some question as to whether they are characteristic of the reaction process or of the product nucleus. In any event, the observation of the same levels in different reactions is of interest.

The nucleus O^{17} can be formed in the $O^{16}(d, p)O^{17}$, $F^{19}(d, \alpha)O^{17}$, and $N^{14}(\alpha, p)O^{17}$ reactions. The first has been studied by Cockcroft and Lewis, and Guggenheimer, Heitler, and Powell,[1] the second by Burcham and Smith,[2] and the third by Haxel.[3] A well-defined group occurs for the ground state (Q_0) value for the first two reactions and the first excited state (Q_1) is clearly found at about 0.85-Mev excitation in both cases. The third reaction does not

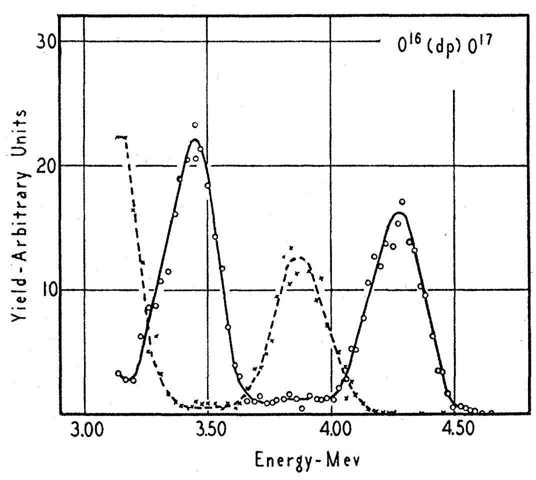

Fig. 1. Yield of protons plotted against energy from $O^{16}(d, p)O^{17}$, using a high counter bias to give differentiation. Two groups are present. The dotted curve is for a reduced bombarding energy. The same groups appear, but with a different relative yield.

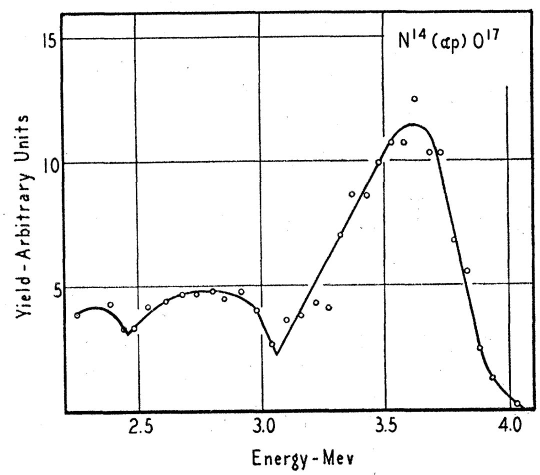

Fig. 2. Yield of protons plotted against energy from $N^{14}(\alpha, p)O^{17}$. Two groups appear corresponding to the same excitation level as found in the reaction of Fig. 1.

show the presence of an excited state at 0.85 Mev in previous work. Since the geometry of natural source work is rather poor, we have studied the $N^{14}(\alpha, p)$ reaction using cyclotron alpha-particles and good geometry. In order to remove systematic errors, we have also studied the $O^{16}(d, p)O^{17}$ reaction using the same absorption cell.

The results of the bombardment of oxygen by deuterons of two energies are shown in Fig. 1. It can be seen that the two proton groups are clearly resolved. The ratio of the yields changes as the bombarding energy changes, there being less relative yield in the excited state as the bombarding energy increases. Table I shows the ratio at four

Table I.

Beam energy	0.575	2.9	3.3	6.2	(d, α)	(α, p)
Ratio yield of Q_1 to Q_0	2.28	1.87	1.43	0.94	1.00	0.3

energies, the highest being taken from the paper of Guggenheimer, Heitler, and Powell, the lowest, Cockcroft and Lewis, and the other two from our new data. The ratios found by Burcham and Lewis for the (d, α) reaction and our own figures for the (α, p) reaction are included.

The alpha-particle bombardment of nitrogen gave the results of Fig. 2. The target was urea. The beam homogeneity is rather worse for alpha-particles, and the yield is less. Nevertheless, two groups of energy 3.93 and 3.15 are present, corresponding to Q-values of -1.31 Mev and -2.12 Mev. The ratio of yields is about 0.3.

We find for the reaction $O^{16}(d, p)O^{17}$, $Q_0=1.75$, $Q_1=0.89$, difference 0.86 Mev, for $N^{14}(\alpha, p)O^{17}$, $Q_0=-1.31$, $Q_1=-2.12$ Mev, difference 0.81 Mev. The two are identical within the experimental error.

The reaction process clearly influences the relative yield as the excited-state group in the (α, p) reaction is one-third as prolific as in the (d, p) or (d, α) reaction. Bombardment by alpha-particles seems to be similar to high energy deuteron bombardment.