TABLE I. Laboratory differential cross sections for neutrons from the $T(d,n)He^4$ reaction for a deuteron energy of 1.80 Mev.

θ_{lab}	0°	30°	60°	90°	120°	150°
$\sigma(\theta_{lab})$ mb/sterad	22.5	18.8	12.5	9.5	8.8	9.7

determined from the reported reaction Q value of 9.4 Mev.[5] Neutron energy spreads vary from ± 0.2 Mev at a mean energy of 18 Mev to nearly ± 1 Mev from 12 to 15 Mev. In correcting the observed activities for the angular distribution of the $T(d,n)He^4$ neutrons, the laboratory differential cross sections shown in Table I were used.[3,6] Relative errors in these values are about ± 10 percent.[7]

A possible cause of the decrease in the $O^{16}(n,p)N^{16}$ cross section above 13.5 Mev is the competitive effect of inelastic scattering. Since O^{16} has a group of levels near 13 Mev,[8] an increase in the inelastic-scattering cross section at the expense of the (n,p) reaction at this energy seems plausible.

A half-life of 7.38 ± 0.05 seconds was obtained for the N^{16} activity, in good agreement with the value of 7.35 ± 0.05 sec reported by Bleuler *et al.*[1]

The writer is indebted to Dr. R. F. Taschek and other members of the 2.5-Mev electrostatic accelerator group for many helpful suggestions.

[5] Hornyak, Lauritsen, Morrison, and Fowler, Revs. Modern Phys. **22**, 291 (1950).
[6] T. F. Stratton and G. D. Freier, Phys. Rev. **88**, 261 (1952).
[7] *Note added in proof.*—Recent measurements by S. J. Bame of this laboratory have shown that the angular distribution of the neutrons from the $T(d,n)He^4$ reaction given in Table I is probably too strongly peaked at small angles. Hence, in Fig. 1, the cross section at 18 Mev should be increased from 40 mb to about 60 mb.
[8] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. **24**, 321 (1952).

PHYSICAL REVIEW VOLUME 93, NUMBER 3 FEBRUARY 1, 1954

Range Distribution of Alpha Particles Following the Decays of Li^8 and B^8

F. C. GILBERT
Radiation Laboratory, Department of Physics, University of California, Berkeley, California
(Received October 2, 1953)

The range distributions of the alpha particles resulting from the decays of Li^8 and B^8 nuclei in nuclear track emulsion have been determined and compared. The range distribution from the decay of Li^8 nuclei is found to be similar to that measured by previous investigators and, within statistical error, the range distribution from the decay of B^8 nuclei is the same as that found from Li^8 nuclei.

IN recent experiments[1] designed to analyze the high-energy disintegration products produced by 375-Mev alpha particles bombarding beryllium, a large number of B^8 and Li^8 hammer tracks (note Fig. 1) were found in the nuclear track emulsions used as detectors. Dr. Walter H. Barkas has suggested that by analyzing the range distribution of the alpha tracks resulting from the reactions

$$\left.\begin{array}{l} B^8 \rightarrow e^+ + Be^{8*} \quad (1) \\ Li^8 \rightarrow e^- + Be^{8*} \quad (2) \end{array}\right\} Be^{8*} \rightarrow 2He^4,$$

the energy level structures arising from these mirror processes in the short-lived Be^8 nuclei may be compared. Although the Be^8 from the decay of Li^8 has been studied by many investigators,[2–4] additional measurements were taken on the alpha particles from reaction (2) as a means of calibration of the method and in the hope of improving the statistics over previous investigations. The alpha-particle range distribution from reaction (1) was studied for the purposes of (*a*) checking the similarity of the two mirror nuclei, Li^8 and B^8, and (*b*) searching for a possible new level in the excited Be^8 nucleus.

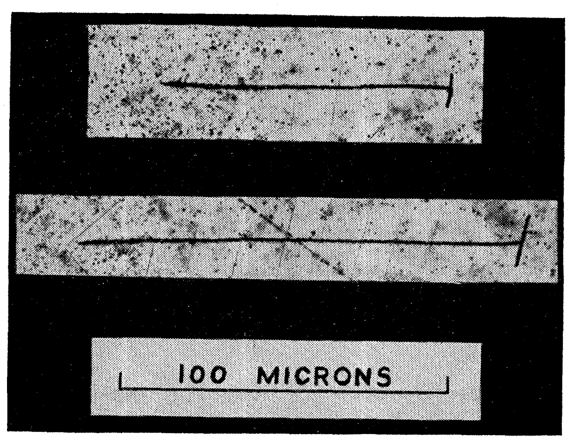

FIG. 1. Photomicrographs of tracks of Li^8 and B^8 nuclei: (top) a 28-Mev Li^8 track, (bottom) a 66-Mev B^8 track.

[1] W. H. Barkas and H. Tyren, Phys. Rev. **89**, 1 (1953); W. H. Barkas, Phys. Rev. **89**, 1019 (1953); R. W. Deutsch, Phys. Rev. **90**, 499 (1953).
[2] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. **24**, 336 (1952).
[3] C. M. Class and S. S. Hanna, Phys. Rev. **89**, 877 (1953).
[4] D. St P. Bunbury, Phys. Rev. **90**, 1121 (1953).

The probability of a second level is enhanced for reaction (1) because of the slightly greater energy (~1 Mev) available in the B^8 nucleus as compared to the Li^8 nucleus.

The B^8 tracks could be differentiated from the Li^8 tracks by the differences in range and in grain density for a given radius of curvature in the cyclotron magnetic field. Owing to the short range of the Li^8 or B^8 tracks penetrating the emulsion, in about one-third of the decays one of the alpha tracks left the emulsion before the end of its range. In these cases the range of the remaining alpha particle was measured from the end of the B^8 or Li^8 track. In the events in which both alpha particles remained in the emulsion, the two ranges were averaged. The later cases provided a means for estimating the errors involved in the measurement of the alpha ranges. Since the two alpha particles come apart with equal energies in their center-of-mass system, the difference in their measured ranges gives an estimate of the errors due to range straggle, recoil of the Be^8 nucleus from the beta decay, indeterminacy of the end points, and human error. In this manner the standard deviation in the measurement of individual alpha ranges was estimated to be about 0.5 micron. The alpha energies as a function of range were determined from a range-energy relation for C-2 emulsions worked out by Wilkins.[5]

The alpha ranges from 100 B^8 disintegrations and 257 Li^8 disintegrations, normalized to 100 for comparison, are shown in Fig. 2. No significant difference is detectable; in particular, no additional long-range alpha particles were found following the decay of B^8. The Li^8 distribution is similar to that found by previous investigators.[2–4]

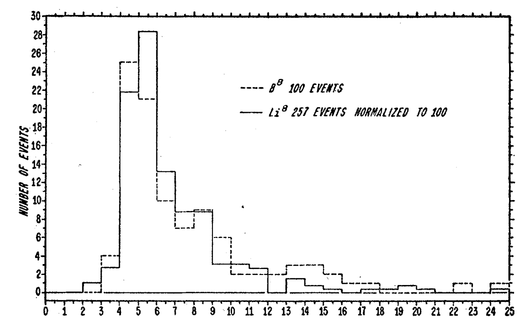

FIG. 2. The alpha-particle range distributions following the decays of 100 B^8 nuclei and 257 Li^8 nuclei. The 257 Li^8 events have been normalized to 100 for comparison.

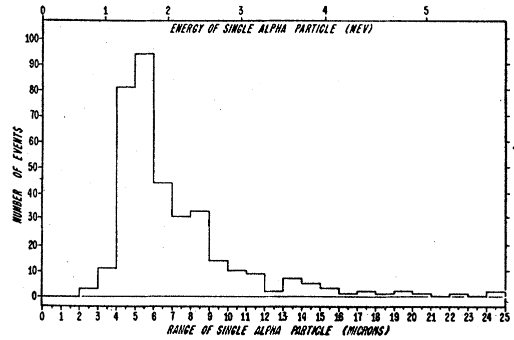

FIG. 3. The combined alpha-particle range distribution following the decay of 357 Be^8 nuclei.

The combined 357 events shown in Fig. 3 have a maximum at about $E_\alpha = 1.5$ Mev and a width at half-maximum, $\Delta E_\alpha = \approx 0.7$ Mev. Near resonance the distribution may be fitted by a single resonance theory due to Wheeler[6] as modified for the alpha penetrability by Bonner *et al.*,[7] where $E_0 = 2.9$ Mev, $\Gamma = 1.2$ Mev, and J, the angular momentum of the excited state of Be^8, is 2. Roughly 15 percent of the decays, principally the higher-energy alpha particles, are not included by this resonance and must be explained by the presence of higher levels in the Be^8 nucleus. It is to be noted that the data may be fitted satisfactorily over the entire energy range of this experiment by the single resonance theory if J is chosen to be 4 in agreement with the analysis by Bonner *et al.*[7]

The presence of the longer-range alpha particles, 15 to 25 microns, from the decay of B^8, and the similarity of the B^8 and Li^8 distributions, suggest that the B^8 beta decay leads to the same energy levels in Be^8 as does the Li^8 beta decay. This is in essential agreement with the interpretation of the positron spectrum of B^8 as measured by Alvarez.[8]

I am particularly indebted to Dr. Walter H. Barkas for his invaluable guidance and to Mrs. Doreen Hornback for having made many of the measurements that were necessary for this experiment.

[5] J. J. Wilkins, Harwell Atomic Energy Research Establishment Report G/R 664 (unpublished).

[6] J. A. Wheeler, Phys. Rev. **59**, 27 (1941).
[7] Bonner, Evans, Malich, and Risser, Phys. Rev. **73**, 885 (1948).
[8] L. Alvarez, Phys. Rev. **80**, 519 (1950).

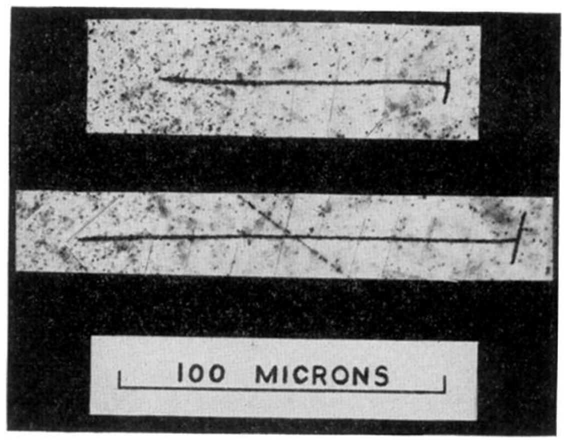

FIG. 1. Photomicrographs of tracks of Li^8 and B^8 nuclei: (top) a 28-Mev Li^8 track, (bottom) a 66-Mev B^8 track.