systematic error that would be caused by a deviation from exact proportionality between pulse height and proton energy in NaI.

In the absence of a direct calibration of the response of sodium iodide to deuterons, deuteron energies were computed by using the known[3,4] Q value for the reaction $Li^7(p, d)Li^6$ leading to the ground state of Li^6 and assuming proportionality between deuteron energy and observed pulse height.

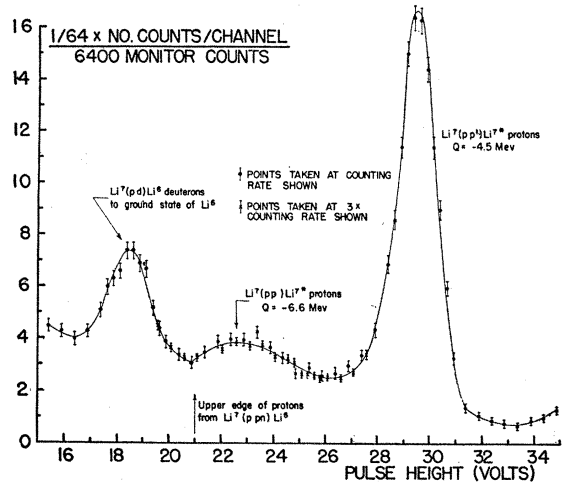

FIG. 2. Low energy portion of the spectrum observed at 90° showing the broad proton group corresponding to a 6.6-Mev state in Li^7. This group is also observed at 30°, 120°, and 150° in the laboratory system, and it appears to have a width approximately twice as large as our experimental resolution at this energy (0.3 Mev). Vertical bars indicate standard deviations of the experimental points.

The spectrum of particles observed at 60° in the laboratory system is shown in Fig. 1. Figure 2 shows part of the spectrum observed at 90°. We have also obtained a differential discriminator spectrum at 120° and oscilloscope photographs of the spectra at 30° and 150°.

Figure 3 summarizes the observed reactions between protons and Li^7. The second excited state in Li^7 is located at 4.56±0.10

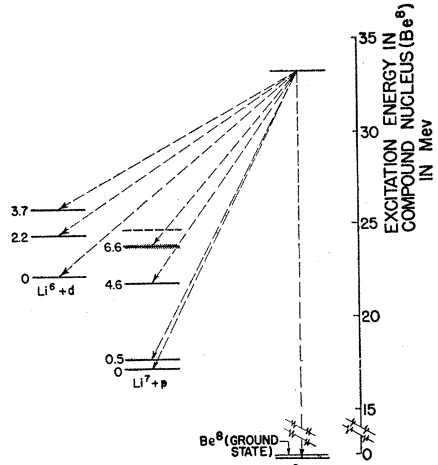

FIG. 3. Schematic representation of all particle groups observed in this experiment which result from the interaction of 18.3-Mev protons with Li^7.

Mev above the ground state, in substantial agreement with the results of Gelinas, Class, and Hanna,[5] and Gove and Harvey.[6] In addition, we observe a broad group corresponding to a new level in Li^7 at 6.56±0.12 Mev. The possible existence of this level has been suggested by Bashkin and Richards.[7] We have not observed a proton group corresponding to a level in Li^7 at 7.54 Mev, as reported by Blair[8] and others,[9,10] although a weak group corresponding to this energy might not be detected above a background which presumably consists of protons from $Li^7(p, pn)Li^6$. (The maximum energy of the continuous distribution arising from this reaction corresponds to an excitation energy in Li^7 of 7.25 Mev.)

The observed deuteron groups suggest levels in Li^6 at 2.2±0.2 and 3.7±0.2 Mev. The first of these was also detected through a weak inelastically scattered proton group from Li^6 (Fig. 1) giving a better value of 2.18±0.12 Mev for the level position, in agreement with a recent determination.[11] The 3.7-Mev level in Li^6 is presumably identical with the state responsible for the gamma-ray observed by Day and Walker[12] in $Be^9(p, \alpha)Li^6$.

A group of α-particles from $Li^7(p, \alpha)\alpha$ was observed with a 12.5 mil thick NaI crystal placed inside the vacuum of the scattering chamber. Comparison with Po−α pulses and use of Taylor's calibration[13] for NaI indicates that these particles arise from the direct break-up of the compound nucleus Be^8.

† Research supported by the AEC and the Higgins Scientific Trust Fund.
[1] J. G. Likely and W. Franzen, Phys. Rev. **87**, 666 (1952).
[2] J. H. Smith, Phys. Rev. **71**, 32 (1947).
[3] Li, Whaling, Fowler, and Lauritsen, Phys. Rev. **83**, 512 (1951).
[4] Strait, Van Patter, Buechner, and Sperduto, Phys. Rev. **81**, 747 (1951).
[5] Gelinas, Class, and Hanna, Phys. Rev. **83**, 1260 (1951).
[6] H. E. Gove and J. A. Harvey, Phys. Rev. **82**, 658 (1951).
[7] S. Bashkin and H. T. Richards, Phys. Rev. **84**, 1124 (1951).
[8] J. M. Blair, as quoted by Bashkin and Richards, reference 7.
[9] R. Holland, private communication from D. R. Inglis.
[10] C. H. Johnson, private communication.
[11] Browne, Williamson, Craig, and Donahue, Phys. Rev. **83**, 179 (1951).
[12] R. B. Day and R. L. Walker, Phys. Rev. **85**, 582 (1952).
[13] Taylor, Jentschke, Remley, Eby, and Kruger, Phys. Rev. **84**, 1034 (1951).

Radiative K-Capture in A^{37}†

C. E. ANDERSON, G. W. WHEELER, AND W. W. WATSON
Yale University, New Haven, Connecticut
(Received June 30, 1952)

IN 1940, Morrison and Schiff[1] predicted the existence of a weak continuous high energy gamma-ray spectrum accompanying K-capture. The energy distribution of this spectrum was calculated for allowed transitions to be

$$(\omega_k/\omega_C)dk=(\alpha/\pi)(W/mc^2)^2(1-\epsilon)^2\epsilon d\epsilon,$$

where $\epsilon=k/W$. W is the energy available for capture and k is the energy of the gamma-ray. The ratio of the total number of gamma-rays to the total number of K-captures is given by

$$\frac{\omega_R}{\omega_C}=\int_0^W\frac{\omega_k dk}{\omega_C}=\frac{\alpha}{12\pi}\left(\frac{W}{mc^2}\right)^2.$$

Up to the present time, the only confirming evidence for this gamma-radiation has been the work of Bradt[2] and Maeder and Preiswerk[3] on Fe^{55}.

Since the ratio ω_R/ω_C is proportional to W^2, radiative K-capture should be more easily observed in A^{37} than in Fe^{55}, for W is 816

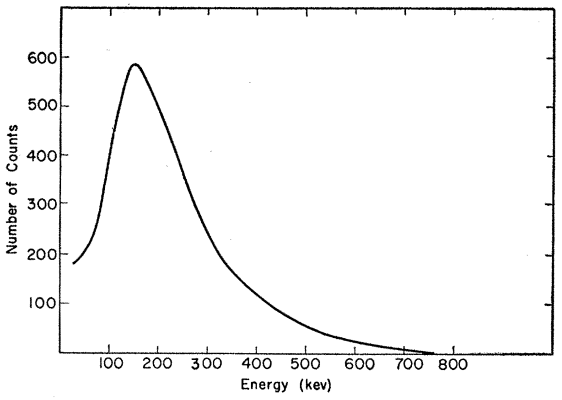

FIG. 1. Pulse-height analysis of A^{37} gamma-radiation.

kev[4] for A^{37} as against 220 kev for Fe^{55}. As it seems reasonable from the *ft* value and from nuclear shell theory that the transition A^{37} to Cl^{37} is allowed, one can make use of the calculations of Morrison and Schiff. By irradiating a 1-cc at STP sample of argon gas enriched in A^{36} to 96 percent in the Brookhaven reactor, we were able to obtain a source strong enough (about 1 mC) to observe the continuous gamma-ray spectrum. Using a scintillation spectrometer we obtained a pulse-height distribution (Fig. 1) which agrees roughly with that to be expected from the predicted distribution. Another analysis by means of a calculated absorption in lead for the theoretical distribution also seems to agree with the absorption curve observed (Fig. 2).

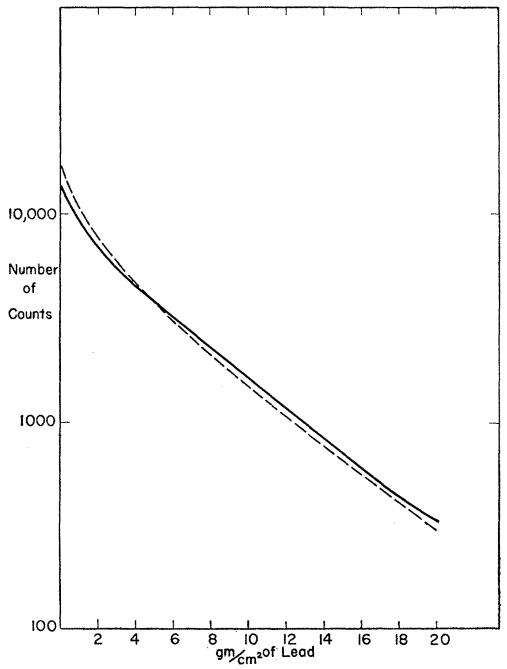

FIG. 2. Absorption curve in lead of A^{37} gamma-radiation. Solid line, calculated curve; dashed line, experimental curve.

Better agreement with the theoretical distribution may be obtained if corrections for the variation of sensitivity with energy of our detecting equipment were to be made. A more careful analysis is in progress. We wish to thank Professors E. C. Pollard and F. Hutchinson for helpful discussion.

† Work performed under the auspices of the AEC.
[1] P. Morrison and L. I. Schiff, Phys. Rev. **58**, 24 (1940).
[2] H. Bradt *et al.*, Helv. Phys. Acta **19**, 222 (1946).
[3] D. Maeder and P. Preiswerk, Phys. Rev. **84**, 595 (1951).
[4] Richards, Smith, and Browne, Phys. Rev. **80**, 524 (1950).

The Total Cross Sections of Positive Pions in Hydrogen*

S. W. BARNES, D. L. CLARK, J. P. PERRY, AND C. E. ANGELL
University of Rochester, Rochester, New York
(Received June 25, 1952)

THE total cross sections of positive pions in hydrogen have been measured for pion energies of 56 Mev and above.[1] Here we report a similar, though preliminary, measurement made at a mean energy of 37 Mev.

The positive pions were produced by 240-Mev protons in the 130-in. Rochester cyclotron when intercepted by an Al target. 50±1 Mev pions emitted at 160°±10° from the proton direction left the vacuum tank through a thin window, passed through a vertically focusing coil, and traveled down the channel of a 3-ft

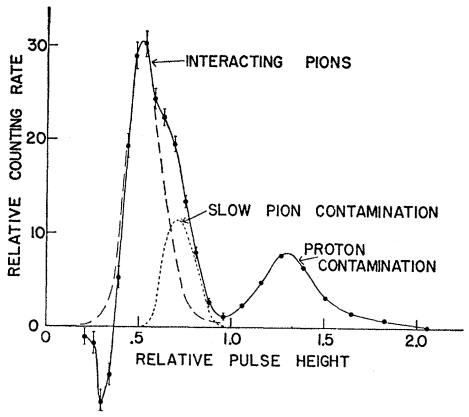

FIG. 1. The solid curve shows the pulse-height distribution for particles stopping in the CH_2 attenuator. The dashed curve is the pulse-height distribution for the incident pions. The dotted curve is the difference.

cubical brass shielding block which housed in the first three crystals of a scintillation counter telescope. These were 1 in.×1 in.×0.2 in. *trans*-stilbene crystals. A fourth crystal, a ½ in. thick, 2 in. diameter disk of *trans*-stilbene, was mounted just outside the outlet of the channel. The pion beam was defined by the first three crystals. The threefold coincidence counting rate was about 2000 a minute and included at 4±1 percent contamination of positive muons, which came mainly from the vicinity of the target.

Observations were alternately made of the attenuation of the pion beam in a solid CH_2 block and in a C block made of three sheets of C. These blocks, which could be interposed between the third and fourth crystals, were of equal thickness and equal stopping power. Their thicknesses were respectively 2.165 g/cm² and 2.679 g/cm². A 0.031-inch Cu sheet between the attenuator and fourth crystal stopped recoiling protons.

The fourth counter was in anticoincidence with the first three so as to record events in the attenuator which removed particles from the beam. The amplitude of the pulse in the second counter for such events was recorded by a 24-channel pulse height analyzer.

After correcting for nonlinearity in the pulse-height measuring circuit the number of pulses observed in each of the 24 channels with no attenuator was subtracted from that observed with the CH_2 attenuator. A typical run gave results which are shown by the solid curve of Fig. 1. The C attenuator gave a similar curve. The dashed curve of Fig. 1 is the pulse-height distribution curve obtained when only the triple coincidences from the first three crystals were being recorded. It is plotted on a reduced vertical scale so that it fits the main peak of the solid curve. The dotted curve is the difference between the above two curves and is believed to represent slow pions which have scattered from the walls of the channel and which are stopped in the attenuator by ionization. The peak at large pulse height is believed to correspond to protons which are stopped by ionization in the attenuator. The four points at small pulse height which fall below the axis are not understood at present.

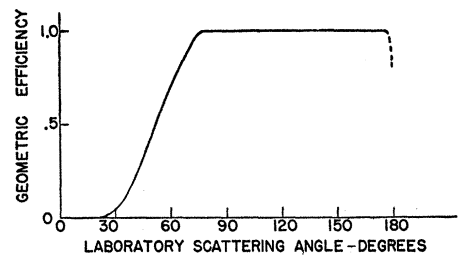

FIG. 2. The efficiency for detecting pions scattered from hydrogen as a function of the laboratory scattering angle.