In order to use this result for our purpose, we must know whether the nuclear scattering at 60 Mev is predominantly attributable to the S or the $P_{3/2}$ state. There are two independent pieces of evidence in favor of the P state. The first is the analysis of the same carbon scattering experiments[4] by Peaslee.[5] He was able to show from the angular distribution of the elastic scattering that the P state gives the major contribution. This is true in particular at the small angles (about 20°) at which the main interference with the Coulomb scattering takes place; here the ratio of P to S amplitude is[5] about 3.

The other evidence comes from the measurement of meson-proton scattering at various energies.[1,6,7] These experiments seem to show a rapid decrease of the S, $I=3/2$ phase shift with decreasing meson energy, although the exact behavior of the phase shift is not yet clear. Near 60 Mev, there are two measurements, one in the cloud chamber of Fowler *et al.*[6] giving zero with considerable uncertainty, and a preliminary one by Steinberger[7] giving $-5°$. In either case, the scattering through 20° would be predominantly P.

We therefore conclude that the nuclear scattering of mesons in the interference experiments of Lederman *et al.* is mostly P, and that therefore the $P_{3/2}$ interaction is attractive, and S (at 100 Mev and over) repulsive, in agreement with theoretical expectation.

It has been assumed here that the elastic scattering of mesons by carbon can be calculated by adding the scattered amplitudes from the individual nucleons, corresponding to the impulse approximation. However, this assumption is used only weakly, namely in the sense that the sign of the interaction with mesons is not reversed when going from individual nucleons to carbon.

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Photoneutron Reaction in Ca^{40}

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PURE calcium has been irradiated with 30-Mev x-rays produced by the electron-synchrotron in the Department of Radiotherapeutics of the University of Cambridge, England. The calcium was approximately 3 cm square and 4 mm thick, covered with a thin layer of paraffin to prevent oxidation, and mounted on a thin piece of distrene in front of a Geiger counter with a thin end window (5 mg/cm^2) of aluminum. The calcium was irradiated for a period of 3.4 sec, and the particles emitted were then counted for 11 sec. This cycle of events, lasting in all 15 sec, was repeated indefinitely. The whole cycle was controlled by a small electric motor geared down to give one complete revolution in 15 sec. Onto the shaft of this motor three Bakelite rings were attached, each with a cam operating a switch and controlling respectively the synchrotron, the counter, and a relay which, when activated, pulled the calcium target, at the end of a metal arm, into the x-ray beam and allowed it to fall in front of the counter when not activated. (The metal arm was not irradiated by the x-ray beam.) The counter was surrounded on all sides by lead 10 cm thick, and a small gap allowed the calcium target to fall in front of the counter. The target and the counter were flushed with unirradiated and therefore nonradioactive air. By this means the counter background was kept constant during the experiment. In addition to counting the pulses from the counter electrically, they were also fed on to one pair of plates of a double beam oscillograph and photographically recorded simultaneously with a 50-cycle sine wave impressed on the second pair of plates. After correcting the decay curve of the radioactivity for counter background the half-life was found to be 1.00±0.05 sec. This value agrees with those found by Huber *et al.*[1] (1.08 sec) and by Boley and Zaffarano[2] (1.1±0.2 sec). Absorption experiments on the β^+-particles have been carried out by placing aluminum absorbers between the counter and the target. From the absorption curve so obtained the maximum energy of the β^+-particles has been estimated by a method described by Feather[3] to be 6.7±0.5 Mev. In this method a correction was applied for the self-absorption of the thick source. This value is in disagreement with the value found by Boley *et al.* but not in disagreement with mass considerations using 38.9747 39.9753 aμ respectively for the atomic masses of K^{39} and Ca^{40} and 16.0 Mev[4] as the threshold for the (γ,n) reaction on Ca^{40}. By comparing the number of particles emitted by a similarly shaped, but thinner copper target, activated under the same geometrical conditions and in the same apparatus, we have estimated the activity induced in calcium by the (γ,n) reaction to be 4.7×10^3 disintegration/gram roentgen at 30 Mev by using the value of 5.8×10^4 disintegrations/gram roentgen for Cu^{63}.[5] A correction was again applied for the self-absorption of the source.

Since x-radiation of this energy is used to treat patients with cancer, it is of importance to know the contribution to the ionization in tissue by the (γ,n) reactions. Bone contains a higher amount of calcium than any other tissue and from the above data together with data from the published literature it can be calculated that the ionization produced by the (γ,n) reaction in bone is negligible (<0.1 percent) compared with the total ionization produced by the x-rays.

It is a pleasure to record the interest and stimulus given to this work by Professor J. S. Mitchell.

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Decay of Ga^{64} and Ga^{65}

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A PREVIOUS assignment[1] of a 48-minute positron activity to Ga^{64} has been disproved by Mukerji and Preiswerk.[2] Ga^{64} has now been found to decay by positron emission with a half-life of 2.6±0.1 minutes. The activity was produced by the $Zn^{64}(p,n)$ reaction, bombarding zinc foil and ZnO enriched in Zn^{64} with 9.5-Mev protons. It was also produced by $Zn^{64}(d,2n)$ in the bombardment of zinc foil with 19-Mev deuterons, and by $Cu^{63}(\alpha,3n)$ with 40-Mev alpha-particles on copper foil. The bombarded targets were dissolved and made 6*N* in HCl, and the Ga was extracted with ether. The ether fractions were washed with 6*N* HCl and evaporated onto the source holders. The decay of the Ga isotopes was followed with a scintillation counter and with a trochoidal analyzer set for positron detection.[3]

Positron activities from the Ga fractions of Zn bombarded with deuterons and of Cu bombarded with alpha-particles, followed in the trochoidal analyzer, showed a component with the half-life of 15 minutes, characteristic of Ga^{65}.[4] Ga sources were mounted in a thick lens β-spectrometer of two percent transmission and four percent resolution, equipped with a helical baffle for the transmission of positrons only. Decay curves were constructed for various current settings, so that the very high background due to 9.45-hour Ga^{66} positrons could be subtracted. Independent Fermi plots were constructed for Ga^{65} obtained by the reactions $Cu^{63}(\alpha,2n)$ and $Zn^{64}(d,n)$, which closely agreed. Two groups of positrons were observed, as shown in Table I.

TABLE I. Positrons from Ga^{65}.

Energy Mev	Abundance percent	log*ft*
2.52 ±0.05	10	6.0
2.1 ±0.1	90	4.7

The author wishes to express his sincere thanks to Professor A. C. Helmholz for suggesting this work and for his advice. Thanks are also due Mr. G. B. Rossi, Mr. W. B. Jones, and the staff of the Crocker Laboratory cyclotron for making the bombardments.

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[3] It has now come to the author's attention that similar results have been obtained at the Oak Ridge National Laboratory (B. L. Cohen, private communication to J. M. Hollander, I. Perlman, and G. T. Seaborg).
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Differential Cross Sections for the Scattering of 58-Mev π^+ Mesons in Hydrogen*

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USING counter techniques similar to those used by Anderson, Fermi, Nagle, and Yodh,[1] the scattering of 58-Mev positive mesons in hydrogen has been investigated. Figure 1 indicates the experimental arrangement. The mesons pass through an opening in the shielding wall and are deflected by a double focusing magnet. The incident beam, defined by the stilbene counters, 1 and 2, strikes the liquid hydrogen target,[2] and the scattered mesons are detected in the large rectangular liquid counters, 3 and 4. Both on entering and on leaving the target, the beam must traverse the vacuum jacket (0.007 inch of aluminum), the radiation shield (0.002 inch of aluminum), and the liquid container (0.003 inch of iron). Measurements are taken at each point alternately with liquid hydrogen in and out of the target cup.

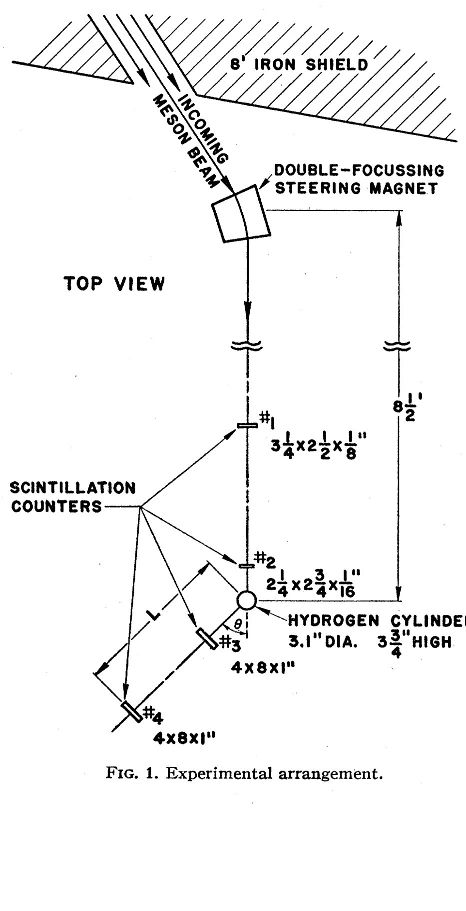

FIG. 1. Experimental arrangement.

From range measurements in carbon, the average energy of the mesons in the hydrogen is determined to be 58 Mev. The width of the energy spread at half-maximum is ±3 Mev, partly due to the initial beam spread and partly due to ionization loss in the hydrogen. The effective angular resolution is measured by rotating the detecting telescope through the main beam. For $L=18.5$ inches, $\Delta\theta=\pm 6.6$ deg and for $L=27.5$ inches, $\Delta\theta=\pm 4.7$ deg, where $\Delta\theta$ is the half-width at half-maximum.

Table I lists the experimental results for the six laboratory angles.

TABLE I. Experimental data.

θ_{lab} deg	L inches	Counts from hydrogen per 10^6 incident particles	Ratio of counts from hydrogen to background	$\Delta\theta$ deg
30	32.5	1.46±2.36	0.02	±3.7
	27.5[a]	2.06±2.11	0.04	±4.7
40	27.5	5.21±1.26	0.19	±4.7
	18.5	4.15±7.14	0.05	±6.6
55	27.5	4.46±2.44	0.26	±4.7
	18.5	13.98±1.89	0.47	±6.6
90	27.5	11.48±1.71	1.96	±4.7
	18.5	20.39±1.59	1.11	±6.6
120	27.5	11.90±2.08	1.44	±4.7
	18.5	30.46±2.32	1.36	±6.6
150	27.5	12.02±2.26	1.04	±4.7
	18.5	32.23±2.26	0.92	±6.6

[a] One inch of carbon in front of counter 4.

From analysis of the range curve, the incident beam is estimated to consist of 89 percent π-mesons. The remaining 11 percent of the particles are μ-mesons and possibly some electrons, and are assumed to undergo negligible scattering in the hydrogen. The effective target thickness is determined to be 0.460 g/cm^2 of hydrogen, based on a scanning of the lateral distribution of the beam by the use of a ⅛-inch wide counter.

By placing counters 3 and 4 between the smaller counters 1 and 2, the efficiency of the detecting telescope is found to be 91 percent. However, 3 percent of the scattered mesons are lost through nuclear collisions in counter 3, and an additional 5 percent are lost in those 30 deg runs where one inch of carbon is placed in front of counter 4 to reduce the background.

A correction is made to the 150-deg data to account for the 10±5 percent of the scattered mesons with insufficient range. Also, 0.08±0.06 millibarn per steradian is added to the uncorrected laboratory cross sections at all angles to account for the fraction of the background which is not detected because of the extra ionization loss in the hydrogen.

TABLE II. Corrected differential cross sections.

Laboratory system		Center-of-mass system	
θ (deg)	$d\sigma/d\Omega$ (mb/sterad)	θ (deg)	$d\sigma/d\Omega$ (mb/sterad)
30	0.33±0.15	36	0.24±0.11
40	0.64±0.10	47	0.48±0.08
55	0.81±0.08	64	0.66±0.06
90	1.21±0.06	101	1.24±0.07
120	1.68±0.09	129	2.10±0.11
150	1.95±0.10	155	2.79±0.15

The corrected differential cross sections in the laboratory system and in the center-of-mass system are given in Table II. The errors quoted combine statistical probable errors with the estimated errors in the two corrections listed above.