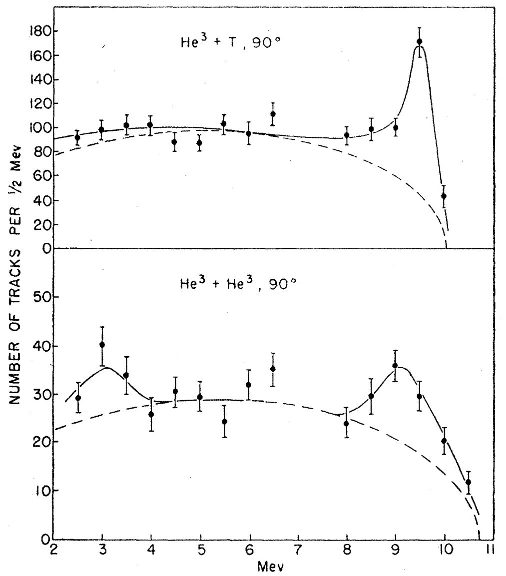

FIG. 2. Energy distribution of protons from He^3+T and He^3+He^3 reactions.

These theoretical curves are represented by the dashed lines in Fig. 2. In Fig. 2(b) there is some evidence for an increase in the intensity of protons below 4 Mev. This is attributed to protons from the decay in flight of the Li^5 nucleus. These protons may take energies up to a maximum of ~3.8 Mev, depending on the energy and width of the Li^5 ground state.

It is a pleasure to acknowledge our indebtedness to Miss H. B. Burrows and Miss M. P. M. Robinson of the University of Liverpool for their careful photographic plate measurements. We are also grateful to the U. S. Atomic Energy Commission for making available to us the He^3 gas used in these experiments. A detailed account of this work is in preparation.

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† Now at the University of Liverpool, Liverpool, England.
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Positive Photomesons from Hydrogen at 0°

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HYDROGEN gas has been bombarded in a high pressure, low temperature target[1] by 322-Mev bremsstrahlung from the Berkeley synchrotron to produce π^+ mesons at 0 ± 4 degrees to the beam. The mesons were bent out of the beam with a magnetic field. The mesons then passed through a lead channel and lead absorbers and were detected in Ilford C-2 200-micron emulsions (see Fig. 1). Data has been obtained for a photon energy of 278 ± 4 Mev (corresponding to a meson kinetic energy of 135 ± 4 Mev in the laboratory system). The absolute differential cross section in the center-of-mass system for the reaction $\gamma+p\rightarrow\pi^++n$ is

$$(d\sigma/d\Omega)(0°,\ 278\ \text{Mev})=(6.2_{-1.9}^{+2.6})\times10^{-30}\ \text{cm}^2\ \text{sterad}^{-1}\ \text{quanta}^{-1}\ \text{proton}^{-1}.$$

This value has been corrected for nuclear interaction in the gas and in the lead absorber, and for decay in flight. The bremsstrahlung spectrum used was corrected for synchrotron target thickness, collimation, and the energy variation in a circulating electron pulse. The pair production background at the detector was reduced by the use of a thick lead absorber that presented many shower lengths to the positrons. The beam monitor was carefully calibrated by the method of Blocker, Kenney, and Panofsky.[2]

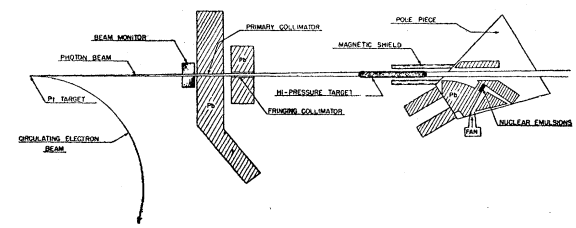

FIG. 1. Schematic diagram of experimental arrangement.

This cross section may be combined with data at other angles for a 275-Mev photon[1] (see Fig. 2) to evaluate the constants in the curve $a+b\cos\theta+c\sin^2\theta$, a form suggested by the phenomenological isobar theory.[3,4] The least squares fit of this equation to the data is

$$d\sigma/d\Omega=(1.46\pm0.16)[(0.72\pm0.15)-(0.45\pm0.10)\cos\theta+\sin^2\theta]\times10^{-29}\ \text{cm}^2\ \text{sterad}^{-1}.$$

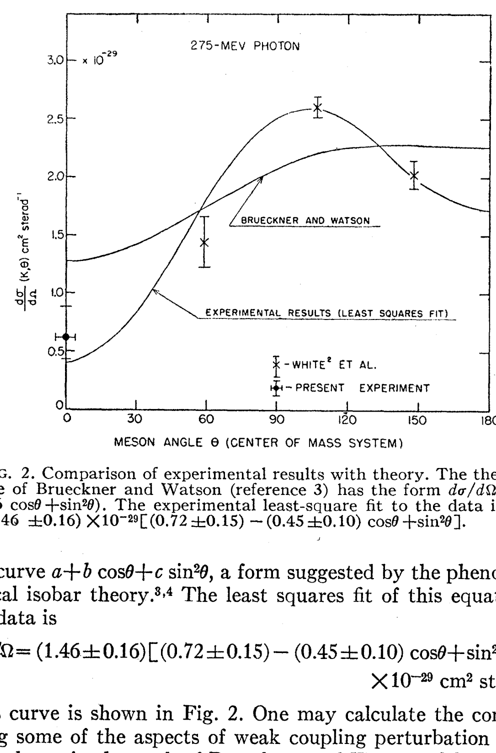

FIG. 2. Comparison of experimental results with theory. The theoretical curve of Brueckner and Watson (reference 3) has the form $d\sigma/d\Omega=C(5.5-1.6\cos\theta+\sin^2\theta)$. The experimental least-square fit to the data is $d\sigma/d\Omega=(1.46\pm0.16)\times10^{-29}[(0.72\pm0.15)-(0.45\pm0.10)\cos\theta+\sin^2\theta]$.

This curve is shown in Fig. 2. One may calculate the constants using some of the aspects of weak coupling perturbation theory as is shown in the work of Brueckner and Watson.[3] The result of this is also shown in Fig. 2. Integration of the experimental curve gives a total cross section of

$$\sigma(278\ \text{Mev})=(2.5\pm0.5)\times10^{-28}\ \text{cm}^2.$$

If one follows the work of Feld[4] and Brueckner and Watson,[3] and assumes that the process goes only by the admixture of a magnetic dipole photon into a total angular momentum state of $\frac{3}{2}$ and an electric dipole photon into a $\frac{1}{2}$ state (also assuming conservation of isotopic spin), the experimental data gives a value of 0.3 for the ratio of $\frac{1}{2}$ to $\frac{3}{2}$ states. A *P* state of the meson-nucleon system could also be formed by the absorption of an electric quadrupole photon. Mixing in this state would not change the form of the equation, $d\sigma/d\Omega=a(b+c\cos\theta+\sin^2\theta)$, but might change the constants to bring the theoretical curve into closer agreement with experiment. Work is being done on the problem at this laboratory.

The theoretical discussions, mentioned above, have often used conclusions taken from meson-nucleon scattering data.[5] Another valid solution to the same data (Yang) has been shown possible and would strongly affect the theoretical photomeson arguments.[6] It seems reasonable that the photo-meson results could be used to choose the correct solution of the meson-nucleon scattering data.

We wish to thank Rod Byrns for his help with the high-pressure target and the crew of the synchrotron for their assistance. Joe Lepore and Steve Gasiorowicz were helpful in discussing some of the theoretical aspects of the subject. A more detailed report will follow.

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Recent Experimental Results on *S* Particles*

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IN an examination of recent cloud-chamber films we found several additional examples of *S* particles which throw new light on the mode of decay of these particles. Previous results[1–4] are consistent with the assumption that the secondaries from *S* particles all have the same range of about 66 g cm^{-2} Pb and consequently that the decay of *S* particles is a two-body process. The new evidence appears to contradict this assumption. Indeed, in two of our recent events the decay particle traverses more than 66 g cm^{-2} of lead before going out of the chamber. In the first case the visible range of the particle is 73 g cm^{-2} of lead, and moreover, since the ionization still appears to be minimum after the particle traverses the last plate, the range of the particle (assumed to be a meson) must be greater than 80 g cm^{-2} of lead. In the second case the visible range is 85 g cm^{-2} of lead. The momentum of a π meson with a range exceeding 85 g cm^{-2} of lead is greater than 240 Mev/c and that of a corresponding μ meson is greater than 209 Mev/c.

In addition we have observed four decay events in which related electron cascades appear (see example in Fig. 1). We can interpret these events by assuming that the *S* particle decays into a charged meson and a photon, or possibly into a charged and a neutral meson. In two events the cascade starts in the plate adjacent to the one in which the *S* particle stops and decays. In these cases the direction of the photon is opposite to that of the charged decay product within 5°. This seems to favor the assumption that the neutral decay product is a photon rather than a π^0 meson (the decay photons of π^0 mesons with a momentum of the order of 200 Mev/c are emitted at an average angle of about 30°). In the remaining two cases the photon materializes in the plate in which the decay occurs. Here the direction of the photon cannot be determined accurately and one can only say that it lies within 15° of the direction opposite to that of the charged decay product.

To date we have found a total of twenty examples of *S* particles. Among these, only the four mentioned above contained electron cascades. In order to test the assumption that all *S* particles undergo a two-body decay process in which a photon is produced, we have computed the probability that among our twenty examples four or fewer electron cascades should have been observed. For a photon energy greater than 150 Mev we have obtained for this probability a conservative upper limit of 10^{-5}. One should, of course, consider the possibility that we may have missed some

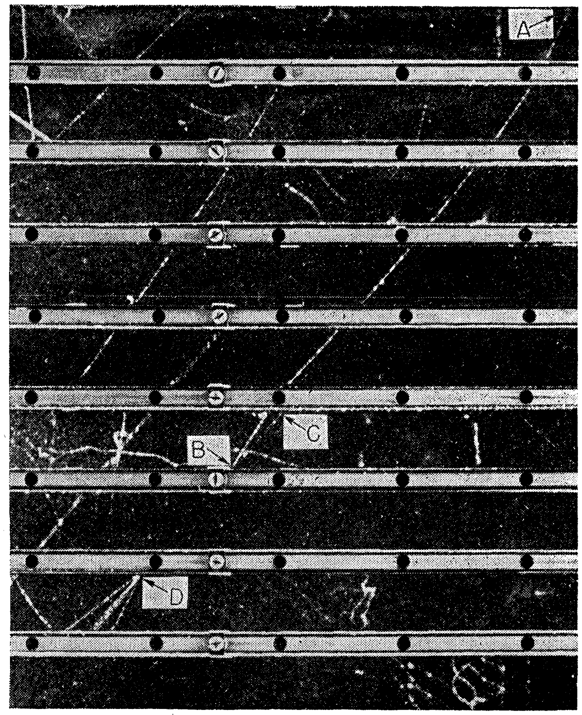

Fig. 1. Example of an *S*-particle decay in which there is a related electron cascade. *AB* is the track of the *S* particle, *BC* is the section of track of the charged decay product which is visible in the illuminated region, and *D* is the point of origin of the electron cascade.

decay processes accompanied by electron cascades. However, even if there had been eight such processes in our sample instead of the four actually detected, a similar computation would yield a probability of about one percent.

Thus, although photons are certainly produced in the decay of some *S* particles, we consider it unlikely that the decay process always gives rise to photons of energy greater than 150 Mev.

* This work was supported in part by the joint program of the U. S. Office of Naval Research and the U. S. Atomic Energy Commission.

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Angular Distributions of Protons from $Na^{23}(d, p)Na^{24}$

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THE angular distributions of the protons from the $Na^{23}(d, p)$-Na^{24} reaction has been observed, using a multiple nuclear plate technique.[1] A thin NaI target evaporated in vacuum on a thin silver foil was mounted at the center of the chamber and was bombarded by a 1.15-Mev deuteron beam collimated to 3 mm diameter from the Tohoku electrostatic generator. The proton group corresponding to the Na^{24} ground state was clearly resolved, and its angular distribution is shown in Fig. 1. The distribution shown in Fig. 2 is that of the sum of the two groups corresponding to the 0.472- and 0.564-Mev levels of Na^{24}.[2] It was obtained in a single plate at each angle.

The intensity ratio at 90° of the ground state group to the sum of the groups corresponding to the two excited states is about 1:2.2, in reasonable agreement with the value 1:(0.7+1.4) given