predicted. An event was classified as simple if the observed ϕ was within 10° of the predicted value, which allows for the Fermi momentum of the target proton, and if the production event showed no charged secondaries. There resulted a small sample which showed no asymmetry (10 up, 12 down).

The Λ events showed no correlation between $\cos\theta$ and observation probability; nor was there a correlation with quality of identification. The events which could be either Λ or θ^0, if interpreted as Λ (the proton being identifiable in all cases), showed no asymmetry (13 up, 14 down). The Λ's gave a mean life in agreement with the value $(2.8 \pm 0.2) \times 10^{-10}$ sec obtained by the Columbia bubble chamber group.[5]

One source of depolarization of these Λ's is a possible decrease of $\bar{P}$ with increasing energy of the incident π^-. The bubble chamber results give some indication of a decrease of $\bar{P}\alpha$ with energy,[1] but no firm conclusion can be drawn at present from the data.

Scattering of Λ's in the production nucleus can be a significant source of depolarization, especially for Λ's produced in lead, the nuclear radius of which is 7×10^{-13}cm. Scattering of the π^- inside the production nucleus before the production event can also contribute to depolarization.

Admixture of Λ's produced by other reactions, especially $\pi^- + p \rightarrow \Sigma^0 + \theta^0$, might greatly reduce polarization effects. If the reactions $\pi^- + p \rightarrow \Lambda + \theta^0$ and $\pi^- + p \rightarrow \Sigma^0 + \theta^0$ are about equally likely[6] and if these reactions are the major sources of Λ's in the present experiment, then as many as 45 of our Λ's produced in lead can be from Σ^0 decays. The polarization of these Λ's is $\frac{1}{3}$ that of the Σ^0's,[7] and may be close to zero. If Σ^0 production gives rise to 45 unpolarized Λ's, then the chance that the remaining 46 Λ's sample a population having $\bar{P}\alpha = 0.40$ is raised to 25%.

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PHOTOPRODUCTION OF POSITIVE PIONS FROM PROTONS*

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The results of the experimental determination of the differential cross sections for the reaction $\gamma + p \rightarrow \pi^+ + n$ at 260 and 290 Mev performed at

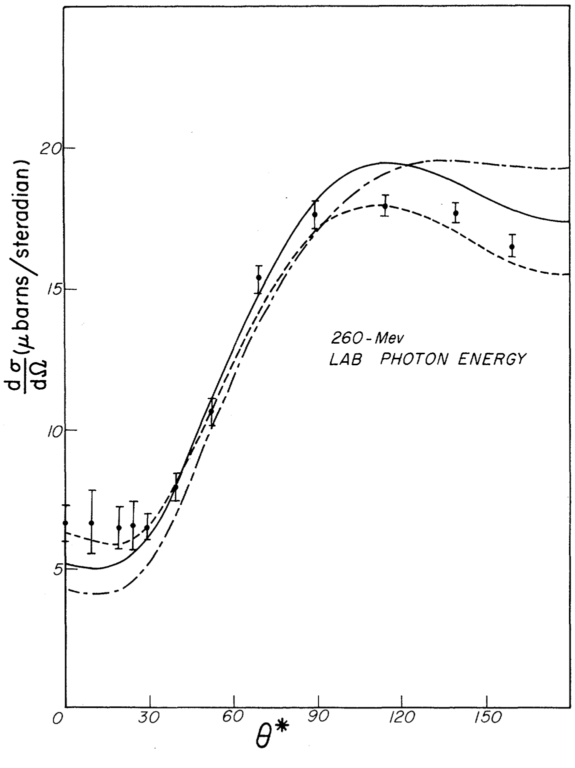

FIG. 1. Angular distribution of positive photopions from hydrogen at 260-Mev photon energy. For explanation of the curves see text.

the Berkeley synchrotron are shown below in Figs. 1 and 2. The equipment and experimental method have been described in detail elsewhere.[1]

The π mesons were detected by counters utilizing the characteristic π - μ decay.[1] The angular distributions were measured in two ranges, 0° to 53° and 28° to 160°, with different counter geometries because of the greatly differing electron background in these two regions. The relative measurements over the forward-angle range were normalized to the absolute cross section measurements in the 28° to 160° interval by least-squares fitting in the overlap region.

The absolute measurements in the backward-angle range were taken with a simpler counter-telescope geometry which was readily amenable to solid-angle calculations. The efficiency of the counter telescope was measured by exposing it to a known flux of positive pions from the 184-inch cyclotron. The major uncertainty in the absolute measurements lies in the error in photon flux determined by the "Cornell" thick-walled ion chamber. A careful recalibration of this instrument will be made in the near future. The 290-Mev data of Fig. 2 is not complete in that the small-angle points are missing. These points are being measured.

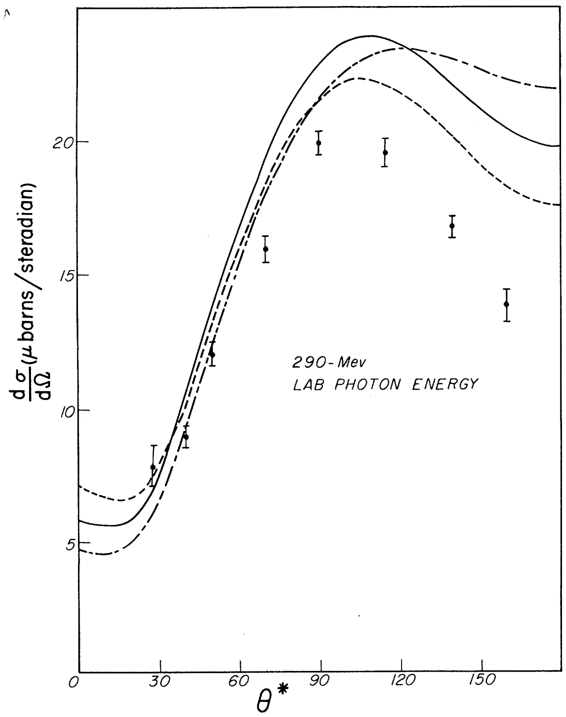

FIG. 2. Angular distribution of positive photopions from hydrogen at 290-Mev photon energy. For explanation of the curves see text.

The theoretical cross sections were calculated from the dispersion-relation formulas as given by Chew et al.[2] except that the F^0 amplitude (Eq. 22.7 of Moravcsik[3]) was divided by a "phase-space" factor, $1 + w/M$, where w is the meson total energy in the barycentric system. The value 0.08 was used for f^2, and the constant $N^{(-)}$ of Eq. (22.6) was set equal to zero.

In our initial calculations the P-wave phase shifts were computed from the effective range relations given by Chew and his collaborators. The S-wave phase shifts were taken to obey the relation

$$2\ \delta_1 + \delta_3 = 0.229\ q\ ,$$

which is suggested by Orear's analysis.[4] The results of these calculations are given by the solid curves in the accompanying figures.

We note first that the theory contains the general features of the angular distributions as well as the energy dependence of the 90° cross sections. On the other hand, there appears to be a definite failure in the quantitative predictions of the theory for photon energies of about 290 Mev and higher. It seemed reasonable to ask to what extent the disagreement between theory and experiment was a reflection of our inadequate knowledge of the experimental quantities that occur in the cross section formula. A partial answer to this question is obtained by investigating the results of varying the small P-wave phase shifts.

As a first attempt we set δ_{11} equal to zero, leaving the other parameters unchanged, and found that the forward cross section was depressed while the backward-angle cross section was increased. One observes that the agreement with experiment becomes even less satisfactory. On the other hand, if, instead, δ_{13} and δ_{31} are set equal to zero (dashed curves in the figures) the forward and backward cross sections are, respectively, increased and lowered with the consequence that the agreement between predicted and theoretical angular distributions is improved. As a third choice we used Anderson's formulas for the three phase shifts δ_{11}, δ_{13}, and δ_{31} (the last two are no longer equal) with the results shown by the "dash-dot" curves in the figures. Empirically, this seems to be the worst choice of all.

We feel that the most important result of our calculations is the discovery that the photoproduction cross section is a very sensitive function of the "small" pion-nucleon scattering phase shifts. This sensitivity has the unfortunate consequence that any attempt to evaluate the detailed success of the photoproduction theory as formulated by Chew *et al.* must be inextricably entangled with a very precise investigation of the scattering problem. To this extent we feel that the calculations described here are significant. It is to be emphasized, however, that we attach no especial significance to the particular choice of *P*-wave phase shifts that gives the best prediction of the experimental results except to the extent that this choice focuses our attention upon certain terms in the dispersion-relation formula.

Examination of the low-energy 90° data seems to indicate that a choice of 0.08 for the coupling is somewhat high. If we choose a value of the coupling constant to fit the theory to the five lowest experimental points of Fig. 3, it is found that 0.072 is somewhat more satisfactory. The high-energy predictions of the theory remain essentially unchanged.

We are indebted to Professor Geoffrey Chew and Dr. Michael Moravcsik for many discussions and suggestions, to Professor C. S. Robinson and Mr. Frank R. Tangherlini for making available to us their results from similar computations, and to Mrs. Marjorie Simmons for the construction of an IBM 650 program.

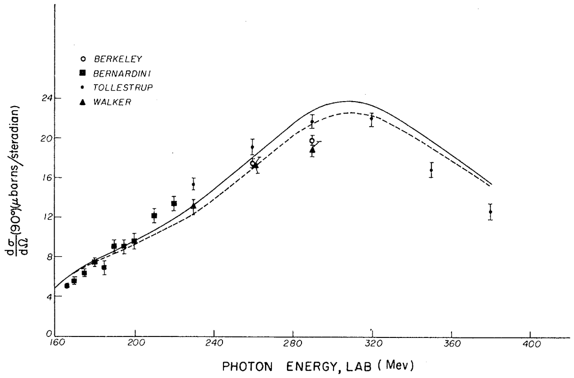

FIG. 3. Differential cross section for photopions from hydrogen at 90° (c.m.) as a function of energy. For explanation of the curves see text. Experimental data is quoted from Beneventano, Bernardini, Carlson-Lee, Stoppini, and Tau, Nuovo cimento 4, 323 (1956); Tollestrup, Keck, and Warlock, Phys. Rev. 99, 220 (1955); and Walker, Teasdale, Paterson, and Vette, Phys. Rev. 99, 210 (1956). The Tollestrup and Walker points have been increased 7% from the originally quoted values.[3]

[*] This work was performed under the auspices of the U. S. Atomic Energy Commission.

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ANTIPROTON ANNIHILATION INTO NEUTRAL PIONS*

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An antiproton annihilation event has been observed in an emulsion stack exposed at the Bevatron,[1] which gives evidence for an annihilation mode in which only neutral pions are produced. As shown in Fig. 1, the antiproton comes to rest and the only visible annihilation products are

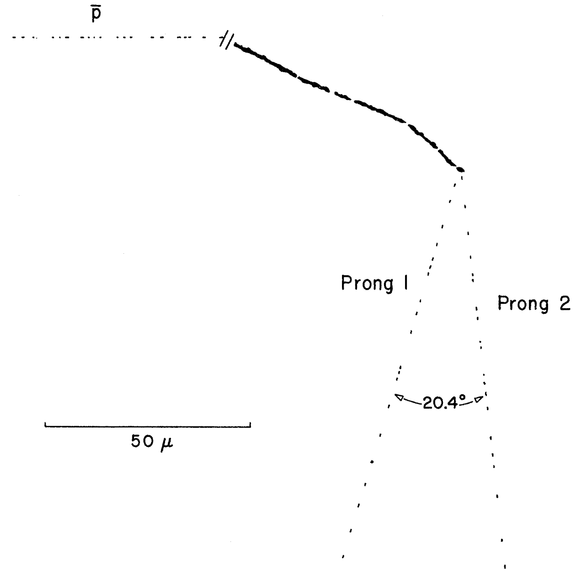

FIG. 1. A projection drawing of the event. The antiproton is represented as it enters the stack at twice minimum ionization and as it annihilates at rest. Prongs 1 and 2 have plateau ionization and are shown to be electrons from scattering measurements. The space angle between the two prongs of the pair is 20.4°.