proton energy. In Ref. 1 the cross section for $T_p=600$ MeV at $\theta_{c.m.}=52°$ is

$$(d\sigma/d\Omega)=(6.2\pm 1)\times 10^{-30}\ \text{cm}^2,$$

which is two orders of magnitude larger than our result at $T_p=1515$ MeV and $\theta=0°$. Since no other measurement of this reaction has been reported at $\theta=0°$, one may not exclude the possibility of a rapid angular variation of the cross section.[9]

We note that He^3 nuclei have been observed in the interaction of high-energy protons with complex nuclei. For example, for 3-BeV incident protons on beryllium at 30°, the laboratory cross section is of the order[10] of $d\sigma/d\Omega \sim 2\times 10^{-30}$ cm² per nucleon; similarly, He^3 nuclei have been observed at 30-BeV incident energy.[11] The production mechanism, however, is presumably different from reactions (1) or (2).

It is a pleasure to thank Dr. F. Turkot for making the exposure possible and for his interest in this work. Dr. T. Yamanouchi and W. Moran assisted us in the early stages of this experiment and made many helpful suggestions. Finally we wish to thank our scanners, Mrs. A. Vilks, Mrs. V. Miller, and G. J. M. Peter, for their careful and diligent work.

[9] O. E. Overseth, R. Heinz, L. Jones, M. Longo, D. Pellet, M. Perl, and F. Martin, Phys. Rev. Letters 13, 59 (1964).

[10] P. A. Piroué and A. J. Smith, Phys. Rev. 148, 1315 (1966).

[11] V. L. Fitch, S. L. Meyer, and P. A. Piroué, Phys. Rev. 126, 1849 (1962).

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Λ Polarization at 90° in $K^+\Lambda$ Photoproduction*

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The Λ polarization and the differential cross section for the reaction $\gamma+p\rightarrow K^+ +\Lambda$ have been measured, using the Caltech synchrotron, at 90° in the c.m. system and at laboratory photon energies of 1100, 1200, and 1300 MeV. Protons from the asymmetric decay of the Λ were detected by counters placed above and below the production plane. Kaons were identified by their behavior in a thick range telescope. Polarization results were $P_\Lambda=+0.34\pm0.09$ at 1100 MeV, $+0.30\pm0.07$ at 1200 MeV, and $+0.08\pm0.07$ at 1300 MeV, where P_Λ was measured in the $\hat{p}_\gamma\times\hat{p}_\Lambda$ direction. The differential cross section was constant with energy at 0.14 ± 0.01 μb/sr. Although the apparent bump in the polarization at 90° at a total energy of ≈1700 MeV adds support to models which invoke a resonance here, no really new conclusions can be reached.

I. INTRODUCTION

Over the past several years, experimenters have measured the differential cross section for the reaction

$$\gamma+p\rightarrow K^+ +\Lambda$$

from near its threshold at 911 MeV to about 500 MeV above threshold.[1–8] In contrast to the violent behavior of the cross section in such reactions as pion photoproduction, the results have a simple appearance. The total cross section at first rises linearly with the kaon center-of-mass momentum, then flattens to remain essentially constant at 2.2 μb between laboratory photon energies of 1000 and 1400 MeV. In the corresponding pionic production reaction

$$\pi^- +p\rightarrow K^0+\Lambda,$$

there is a broad, prominent bump at a total energy of about 1700 MeV[9]; no trace of it appears here. The photoproduction angular distribution is isotropic near threshold, peaks increasingly forward with increasing energy to 1200 MeV,[1–4,6,7] and appears to have flattened somewhat at 1400 MeV.[8] All of the data are very well fitted by quadratics in cosθ.

The polarization of the Λ hyperons has also been measured in several experiments.[5,10] Most measurements have been made near 90° in the c.m. system. The results indicate that the polarization rises to about +0.4 in

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[1] P. L. Donoho and R. L. Walker, Phys. Rev. 112, 981 (1958).

[2] B. D. McDaniel, A. Silverman, R. R. Wilson, and G. Cortellessa, Phys. Rev. 115, 1039 (1959).

[3] N. M. Brody, A. M. Wetherell, and R. L. Walker, Phys. Rev. 119, 1710 (1960).

[4] R. L. Anderson, E. Gabathuler, D. Jones, B. D. McDaniel, and A. J. Sadoff, Phys. Rev. Letters 9, 131 (1962).

[5] H. Thom, E. Gabathuler, D. Jones, B. D. McDaniel, and W. M. Woodward, Phys. Rev. Letters 11, 433 (1963).

[6] A. J. Sadoff, R. L. Anderson, E. Gabathuler, and D. Jones, Bull. Am. Phys. Soc . 9, 34 (1964).

[7] C. W. Peck, Phys. Rev. 135, B830 (1964).

[8] N. Stanton, N. B. Mistry, S. Mori, and A. J. Sadoff, Bull. Am. Phys. Soc. 10, 447 (1965); N. Stanton, Ph.D. thesis, Cornell University, 1965 (unpublished).

[9] Data from several sources is given by G. T. Hoff, Phys. Rev. 131, 1302 (1963).

[10] B. Borgia, M. Grilli, P. Joos, L. Mezzetti, M. Nigro, E. Schiavuta, and F. Villa, Nuovo Cimento 32, 218 (1964).

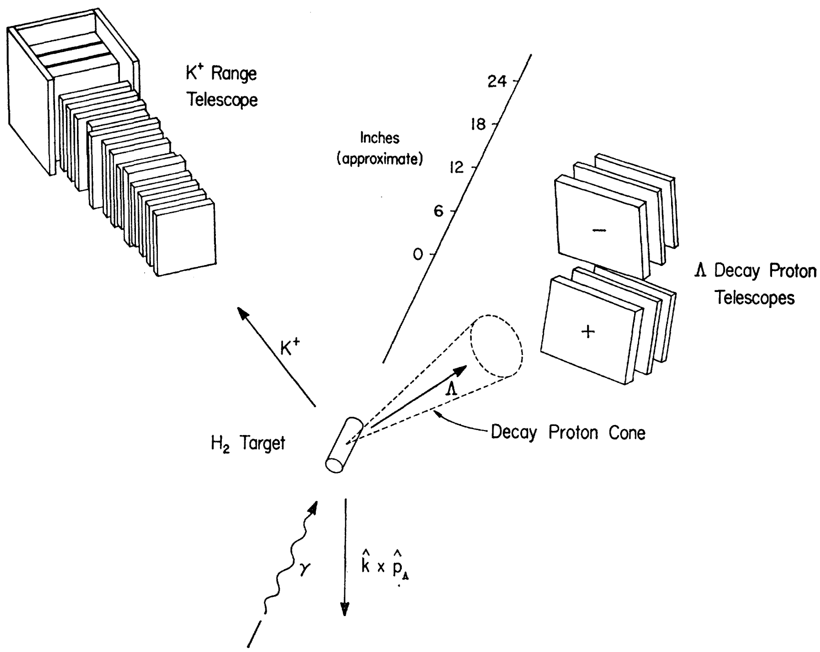

FIG. 1. Perspective view of the apparatus.

the $\hat{p}_\gamma \times \hat{p}_\Lambda$ direction near 1050 MeV. The objects of the present experiment were to overlap with these measurements and to extend them as far as was possible with the Caltech synchrotron. Accordingly, measurements were made at laboratory photon energies of 1100, 1200, and 1300 MeV at a 90° c.m. angle. At the highest energy our results indicate that the polarization has decreased, so that a broad bump centered at perhaps 1100 MeV is suggested. Although the data may add support for models which include effects of resonances near 1700 MeV, we are unable to draw any new conclusions from them.

The experiment also yielded differential cross-section measurements at the same points. The cross section at 90° appears to be constant over the region studied.

II. EXPERIMENTAL METHOD

At the photon energies investigated, 90° in the c.m. system corresponds to laboratory angles near 40° for the kaon and 23° for the hyperon. The maximum proton angle in the Λ decay is of the order of 8°. Kaon kinetic energies range from 180 MeV at the 1100-MeV point to 290 MeV at the 1300-MeV point. As in other $K^+\Lambda$ photoproduction experiments, the Λ kinematics and photon energy were determined by measuring both the angle and energy of the kaon. Other reactions with an associated kaon were eliminated by an appropriate choice of bremsstrahlung end-point energy. As is usual, the Λ polarization was measured by observing the up-down asymmetry of the charged decay mode with respect to the production plane.

A perspective drawing of the apparatus is shown in Fig. 1, and a more detailed plan view is given in Fig. 2. The most important departure from previous experiments of this kind was the use of a range telescope rather than a magnetic spectrometer as the kaon detector. It was chosen over other methods partly to achieve the high counting rates necessary to make the polarization measurement in a reasonably short time. In practice, rates of the order of 20 events/h were achieved, comparable to the rates obtained by Peck[7] without the Λ-detection requirement. The penalty was an uncertainty in the detection efficiency, for the most part because of nuclear interactions in the telescope.

A liquid-hydrogen target was illuminated by a bremsstrahlung beam at the Caltech synchrotron. The beam was generated by spilling the circulating electrons onto a tantalum radiator once per second for about 120 msec, with the production of about 10^9 equivalent quanta. The beam was defined by a rectangular lead collimator and "scraped" by two rectangular apertures, between which was placed a permanent sweeping magnet. At the target about 4.7 m from the radiator, the beam was 2.5 cm high and 2 cm wide, with a vertical standard deviation of 0.76 cm. The total energy in the beam was monitored by an ionization chamber 14 m further downstream. The target was a stainless-steel foil cylinder with 0.005-in. Mylar end caps, and was 6 in. long and 2 in. in diam. The vacuum chamber around the target had long Mylar-capped "snouts" along the beam to eliminate spurious particle sources near the target.

The Λ-decay proton was observed in one of two symmetrically placed telescopes. Each consisted of a Lucite Čerenkov counter (*in veto*) followed by two scintillators. The rear scintillator was the smallest and defined the acceptance aperture. It subtended a solid angle of 0.025 sr. In front of the Čerenkov counter was as much polyethylene as could be used without stopping the

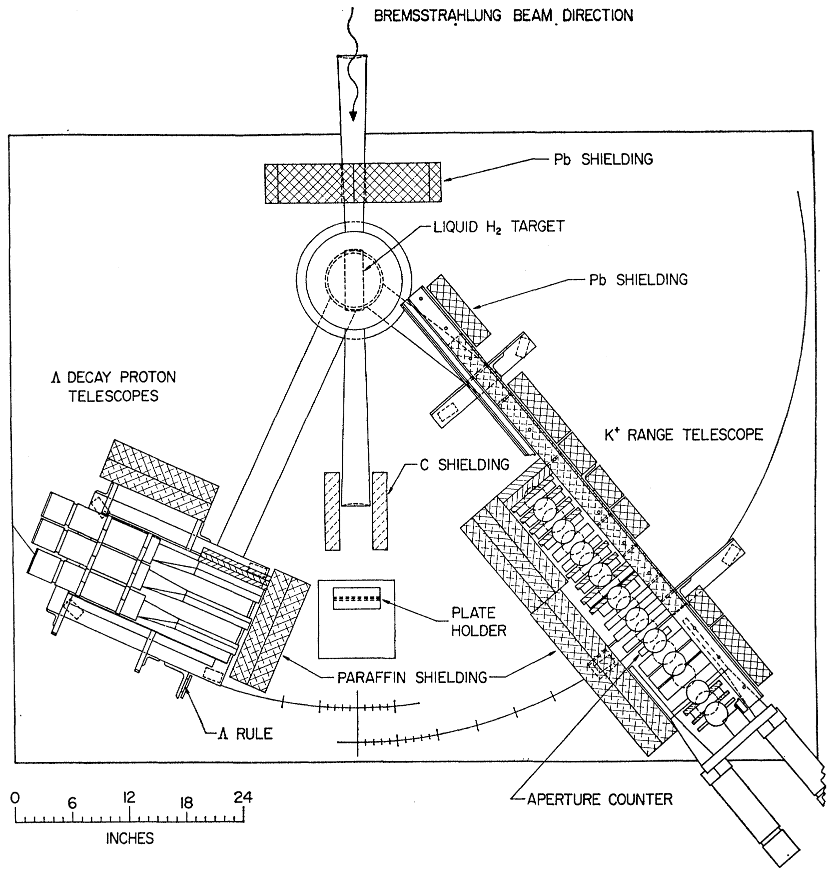

FIG. 2. Plan view of the counter arrays.

slowest of the Λ-decay protons. The telescopes were interchanged several times during each run to eliminate the effects of any constant difference in detection efficiency between them.

The range telescope has been described elsewhere[11]; here, we will present just those features pertinent to the polarization and cross-section measurements. It consisted of 15 to 18 plastic scintillators, depending upon the kaon energy, and two Lucite Čerenkov counters which were used to veto electrons and fast pions. Only particles which stopped in three thick scintillators near the end were accepted. Kaon decay products were monitored by side counters as a check on the operation of the system, but were not required. A 4 in.×4 in. aperture counter near the end of the system subtended a solid angle of 0.0067 sr at the target. Other counters were made considerably larger so that the losses due to multiple scattering would be quite small. The angular resolution function of the telescope at constant kaon energy was nearly triangular. The thickness of the stopping section was chosen to permit an acceptance band of 35 MeV in the kaon kinetic energy. The spread of photon energies introduced by this range spread was equal to that introduced by the angular aperture. Calculated photon energy resolution functions are given in Fig. 3. The increase in width with energy reflects the increase in the derivatives of photon energy with respect to both kaon angle and kaon energy.

A 5-nsec coincidence circuit selected events triggering the first counter and the aperture counter of the telescope but neither of the Čerenkov counters. For such events, fast linear gates were opened, and the outputs of the scintillators in the telescope were passed to the slower (50 nsec) logic. In addition, a pair of 5-nsec circuits determined if a coincident slow particle passed through either of the Λ-decay telescopes. If one of them was present and if a set of pulse-height criteria was satisfied by the telescope scintillator outputs, all of the range-telescope scintillator pulses were digitized and recorded, along with information as to which Λ-decay counter triggered, for later computer analysis.[12] The computer selection of kaons essentially consisted of requiring an event in which the pulse heights produced a statistically good fit to the Bragg curve. The program established which of the recorded events were most probably kaons and provided an estimate of the background in the kaon region.

One check on the behavior of the kaon detection

[11] D. E. Groom and J. H. Marshall, Nucl. Instr. Methods **46**, 293 (1967).

[12] D. E. Groom and J. H. Marshall, Rev. Sci. Instr. **33**, 1249 (1962).

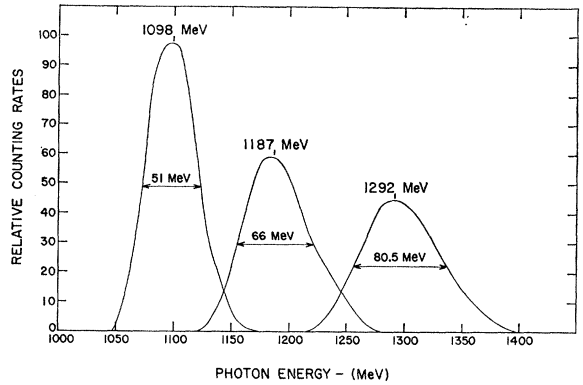

FIG. 3. Photon energy-resolution functions at the operating points. Because of uncertainties in the range and in the range-energy relationship, the positions of the means are uncertain by the amounts listed in Table I.

scheme was afforded by measuring the kaon counting rate as a function of the bremsstrahlung end-point energy. The expected response was calculated from the shape of the bremsstrahlung spectrum and the resolution functions of Fig. 3. Results of such runs are given in Fig. 4. Below kinematic threshold, the counting rate for kaon-like events was quite small and the distribution characteristic of kaons was absent.

In addition, a Monte Carlo calculation of the fraction of kaon events which should be accompanied by side-counter pulses from decay products yielded 0.278 ± 0.023 The observed ratio was 0.294 ± 0.016.

No particularly convenient reaction was discovered which would serve to define the production plane; instead, we were dependent upon careful surveys. Just downstream of the target was mounted a plateholder in which a reticule consisting of tungsten wires on a Lucite plate could be accurately repositioned. Glass-backed photographic plates were exposed every few hours during the running and scanned with a recording

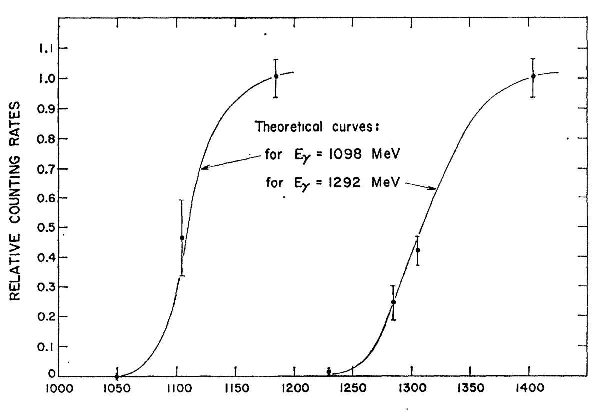

FIG. 4. K^+ excitation curves. The experimental points have been displaced upward by 5 MeV and normalized to fit the calculated curves at the maximum energy.

densitometer to obtain the beam profile and locate the maximum. By this method, the mean of the beam intensity distribution could be located to within 0.015 in. in the laboratory. Behind the Λ-decay telescopes, a 4-ft precision rule was mounted vertically. The beam line determined from the plate measurements and a cross-hair marking in the center of the range telescope aperture were used to define the production plane. The intersection of this plane with the rule was reproducible to 0.019 in. The beam mean position error reflected into 0.025 in. at the rule, for a net uncertainty of 0.031 in. at the rule or 0.8 mrad at the target for the position of the production plane. This, in turn, produced an uncertainity of ±0.007 in the observed up-down asymmetry. The Λ telescopes themselves were measured with respect to the rule to ±0.005 in. after each interchange.

III. Λ POLARIZATION

In the Λ c.m. system, the decay proton distribution is given by

$$f(\theta)d\Omega=(1+\alpha P_\Lambda\cos\theta)d\Omega/4\pi,$$

where θ is the polar angle with respect to the $\hat{p}_\gamma\times\hat{p}_\Lambda$ direction. Here α has the value $+0.62\pm0.07$.[13] If the distribution is mapped into the laboratory and integrated over the decay telescopes and kinematic variables one may write

$$f_{+(-)}=\tfrac{1}{2}F[1+(-)\alpha P_\Lambda G]$$

for the probability of a proton being detected by the telescope in the $+(-)$ position.[14] F and G have been calculated by a sixfold Simpson's-rule integration. For our apparatus, F ranged from 0.37 to 0.51 and G was typically 0.74. The observed number of events N_+ and N_- in the telescopes in the $+$ and $-$ positions distribute about means proportional to f_+ and f_-, and one obtains

$$\alpha P_\Lambda=\frac{1}{G}\left(\frac{N_+-N_-}{N_++N_-}\right)\pm\frac{1}{(N_++N_-)^{1/2}}\frac{1}{G}\left[1-\left(\frac{N_+-N_-}{N_++N_-}\right)^2\right]^{1/2}.$$

In the second term we have inserted the asymmetry as an estimator of $\alpha P_\Lambda G$. About 1000 counts per point were taken in order to obtain a statistical accuracy of about 0.07 in P_Λ.

In practice, the counters were not quite identical. The deviations from symmetric counter placement were calculated from the measurements discussed in the previous section and these geometric corrections were made to the data on a run-to-run basis.

[13] J. H. Cronin and O. E. Overseth, Phys. Rev. **129**, 1795 (1963).
[14] We avoid the usual up-down notation because of the unfortunate fact that $\hat{p}_\gamma\times\hat{p}_\Lambda$ pointed downward in this experiment.

TABLE 1. The polariaztion of photoproduced Λ particles at $\theta_{c.m.}=90°$.

Nominal photon energy	1100 MeV	1200 MeV	1300 MeV
$\bar{k}$ (MeV)	1098±5.3	1187±8.5	1292±11.6
δk^{a} (MeV)	25.5	33.0	40.3
$\theta_{c.m.}$	89.9°	90.2°	89.8°
$\delta\theta_{c.m.}{}^{a}$	5.1°	4.6°	4.3°
F	0.366	0.451	0.512
G	0.777	0.731	0.703
Asymmetry computed from raw data	0.127±0.031	0.130±0.027	0.051±0.027
Asymmetry with geometrical corrections	0.118±0.031	0.119±0.027	0.034±0.027
Kaon fraction	0.720±0.030	0.888±0.031	0.955±0.038
Asymmetry after all corrections	0.162±0.043	0.134±0.030	0.036±0.028
αP_{Λ}	0.209±0.055	0.183±0.042	0.051±0.040
$P_{\Lambda}{}^{b}$	+0.337±0.089	+0.296±0.067	+0.082±0.065

[a] Half-width of the resolution function at half-maximum.
[b] Only statistical errors are included. The estimated systematic error is ±0.03, and the value of α was taken as 0.62±0.07 (Ref. 13).

As has been mentioned, interchanging the counters tended to eliminate constant detection-efficiency differences from the data. In addition, the asymmetry $(N_A-N_B)/(N_A+N_B)$ was computed, where A and B label the counters rather than their positions. The results indicated an intrinsic asymmetry of less than 0.03. There was still the possible difficulty of efficiency changing with time. Most of the events recorded for computer analysis were not kaon events, and they provided a continued monitor on the symmetric operation of the counters. It appeared that at most a systematic error of ±0.01 might exist in the asymmetry because of such electronic effects.

A synopsis of the results is presented in Table I. "Kaon fraction" refers to the fraction of kaon-like events which were not background. The background fraction could be reduced by a factor of 2 or more by permitting the computer to impose more stringent selection criteria, with negligible change in the corrected asymmetry. The error in the production plane position when combined with the limit on the counter-asymmetry error implied a possible systematic error of ±0.03 in the Λ polarization. The errors quoted in the table are statistical only.

When the data were examined on a run-by-run basis, somewhat larger asymmetry excursions for the kaon events were observed than were statistically probable. All of the checks based on the nonkaon events in the same data were well behaved, and a complete explanation was not found.

Our results, together with those of the groups at Cornell[5] and Frascati,[10] are plotted in Fig. 5. The dotted curves are calculated from a resonance model of Gourdin and Dufour,[15] in which the polarization arises

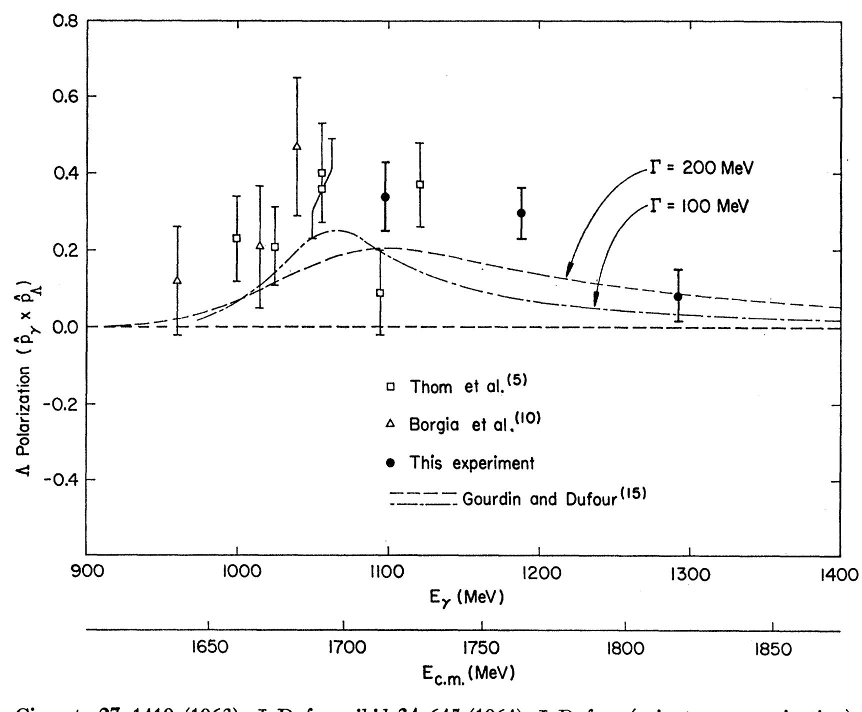

FIG. 5. Polarization of Λ hyperons in photoproduction near 90°.

[15] M. Gourdin and J. Dufour, Nuovo Cimento **27**, 1410 (1963); J. Dufour, *ibid.* 34, 645 (1964); J. Dufour (private communication).

TABLE II. Differential cross section at 90°.

Nominal photon energy	1100 MeV	1200 MeV	1300 MeV
Y	861 ± 54	1290 ± 68	1430 ± 89
Λ telescope efficiency	$0.244\ \pm0.005$	$0.301\ \pm0.006$	$0.341\ \pm0.007$
Kaon-decay veto correction	$0.716\ \pm0.016$	$0.716\ \pm0.016$	$0.716\ \pm0.016$
Analysis efficiency	$0.850\ \pm0.036$	$0.848\ \pm0.036$	$0.887\ \pm0.038$
Nuclear absorption	$0.836\ \pm0.032$	$0.766\ \pm0.046$	$0.694\ \pm0.060$
Multiple scattering	$0.97\ \ \pm0.01$	$0.97\ \ \pm0.01$	$0.97\ \ \pm0.01$
Decay in flight	$0.629\ \pm0.037$	$0.655\ \pm0.034$	$0.690\ \pm0.034$
Accidental veto correction	$0.832\ \pm0.015$	$0.831\ \pm0.016$	$0.856\ \pm0.022$
Net efficiency (η)	$0.0630\pm9.2\%$	$0.0739\pm9.9\%$	$0.0861\pm11.7\%$
$\langle d\sigma/d\Omega\rangle_{\rm av}$	0.139 μb/sr	0.143 μb/sr	0.143 μb/sr
Statistical error	6.3%	5.2%	6.1%
rms systematic error	9.4%	10.1%	11.9%

from the interference of an $N^*_{1/2}(\frac{5}{2}^+, 1688)$ resonance term with other amplitudes. Γ refers to the assumed width of the resonance.

IV. PHOTOPRODUCTION CROSS SECTION

Although the experiment was primarily designed to measure the Λ polarization, cross-section data were also obtained. The accuracy of these data was limited primarily by uncertainties in the efficiency of the detection scheme and in the nuclear absorption corrections.

The total number of kaon counts (Y) and the differential cross section averaged over the system acceptance may be related as follows:

$$Y=\eta\kappa\left\langle\frac{d\sigma}{d\Omega}\right\rangle_{\rm av}.$$

Here κ is the product of well-known kinematic factors, constants characteristic of the target and detection system, and the amount of beam which passed through the target. η is the efficiency of the detection system.

The various factors contributing to η in the present experiment are perhaps most concisely discussed with the aid of Table II. The Λ-telescope efficiency was computed from the geometric efficiency F introduced in the last section, the branching ratio for Λ decaying into its charged mode, and a small correction arising from the possibility of detecting the π^- from the Λ decay. Losses due to kaon decay products accidentally vetoing events were computed by a Monte Carlo method as part of the side-counter efficiency calculation discussed above.

The statistical nature of the analysis and detection schemes led to the loss of some events in which the particle behaved in an unusual way. The extent of such losses was partly calculated and partly determined by a Monte Carlo simulation. During some runs, it was possible for the pulse from counter 12 to saturate the pulse-height analyzer if the particle stopped in the first 7% of the stopping section; such events were disregarded. These and similar small corrections are grouped under "analysis efficiency" in the table.

Nuclear absorption was estimated by assuming a total

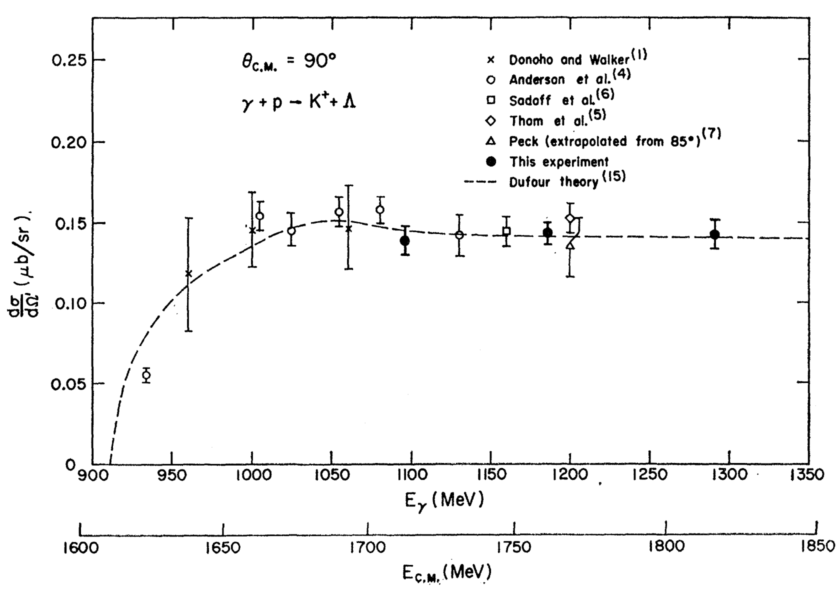

FIG. 6. The differential cross section for the reaction $\gamma+p\rightarrow K^++\Lambda$ near 90°.

cross section of 16±3 mb for hydrogen[16] and 96.5±8.5 mb for carbon,[17] independent of energy. The loss varied from 17% to 30%, and in the worst case was uncertain by about 9%.

Losses due to multiple scattering, decay of kaons in flight, and accidental vetos were calculated in the standard way. Results are given in the table.

The quoted statistical error is a combination of the usual counting error and that incurred in the background subtraction.[11] The systematic error combines the error in η, discussed above, with those in the beam monitoring procedure, effective target thickness, etc. The cross-section results are listed in the table and illustrated in Fig. 6, along with previous results and a calculation based on the resonance model of Gourdin and Dufour.[15]

V. CONCLUSIONS

The results of this experiment corroborate the evidence from other experiments that photoproduced Λ hyperons exhibit a large polarization at $\theta_{\mathrm{c.m.}}=90°$ in the 1100-MeV region; in addition, they suggest that at higher energies the polarization decreases. The differential cross section at $\theta_{\mathrm{c.m.}}=90°$ remains flat to 1300 MeV; Stanton has more recently obtained approximately the same result at 1400 MeV.[8]

The only theoretical attempts to understand the hyperon-photoproduction results have been the phenomenological resonance models of various authors.[15,18,19] In these models, the amplitude is approximated as the sum of terms arising from single-particle and resonance-exchange contributions. The most recent such analysis, by Thom,[19] incorporates the present data. She observes that while a resonance contribution is necessary to produce the polarization, a resonance in any one of several angular momentum states will explain the data.

ACKNOWLEDGMENTS

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[16] J. E. Lannutti, S. Goldhaber, G. Goldhaber, W. W. Chupp, S. Giambuzzi, C. Marchi, G. Quareni, and A. Wataghin, Phys. Rev. **109**, 2121 (1958); T. F. Kycia, University of California Radiation Laboratory Report No. UCRL87-53 (unpublished).

[17] L. T. Kerth, T. F. Kycia, and L. van Rossum, Phys. Rev. **109**, 1784 (1958).

[18] N. A. Beauchamp and W. G. Holladay, Phys. Rev. **131**, 2719 (1963); S. Hatsukade and H. J. Schnitzer, *ibid.* **128**, 468 (1962); **132**, 1301 (1963); Fayyazuddin, *ibid.* **123**, 1882 (1961); **134**, B182 (1964). The differences between these various models are discussed in Ref. 19.

[19] H. Thom, Phys. Rev. **151**, 1322 (1966).

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Neutral Decay of the ω Meson*

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The reaction $\pi^-+p\rightarrow\omega+n$ at 1.2 BeV/c was detected by counter techniques. Recoil neutrons were detected in a scintillation counter array at $\theta_n=20°\pm2°$, and their velocity determined by a time-of-flight measurement. Measurement of the neutron direction and velocity determined the ω mass with resolution ±15 MeV, and enabled separation of ω production from background. Scintillation counters surrounding the hydrogen target distinguished charged from neutral ω decays, yielding a branching ratio: $\Gamma_{\mathrm{neutral}}/\Gamma_{\mathrm{charged}}=0.124\pm0.021$. Neutral ω decays were directly observed by conversion of the resulting γ rays in a lead-plate spark-chamber array. Events with three observed γ's were fitted to the decay $\omega\rightarrow\pi^0+\gamma\rightarrow3\gamma$ (a two-constraint fit). Twenty-six fits with $\chi^2<5$ were found, of which five are estimated to be background. If $\omega\rightarrow\pi^0+\gamma$ is the only neutral mode, then we expect 29 observed $\pi^0\gamma$ decays, as calculated from the recoil-neutron measurements and spark-chamber efficiency. Thus our data give clear evidence that the mode $\omega\rightarrow\pi^0+\gamma$ represents a substantial fraction (consistent with 100%) of the ω neutral decays.

It is known that approximately 10% of the ω-meson decay is into neutral modes.[1] Experimental data concerning the neutral decay modes[2] have supported the theoretically expected result that $\omega\rightarrow\pi^0+\gamma$ is the dominant mode. In the experiment reported here, performed at the Pennsylvania-Princeton accelerator,

* Work supported in part by the U. S. Atomic Energy Commission.

[1] C. Alff, D. Berley, D. Colley, N. Gelfand, U. Nauenberg, D. Miller, J. Schultz, J. Steinberger, T. Tan, H. Bruger, P. Kramer, and R. Plano, Phys. Rev. Letters **9**, 325 (1962); R. Kraemer, L. Madansky, M. Meer, M. Nussbaum, A. Pevsner, C. Richardson, R. Strand, R. Zdanis, T. Fields, S. Orenstein, and T. Toohig, Phys. Rev. **136**, B496 (1964); S. M. Flatte, D. O. Huwe, J. J. Murray, J. Button-Shafer, F. T. Solmitz, M. L. Stevenson, and C. Wohl, Phys. Rev. Letters **14**, 1095 (1965). For a compilation of results see A. H. Rosenfeld, A. Barbaro-Galtieri, W. J. Podolsky, L. R. Price, R. Soding, C. G. Wohl, M. Roos, and W. J. Willis, Rev. Mod. Phys. **39**, 22 (1967).

[2] V. V. Barmin, A. G. Dololenko, Y. S. Kestnikov, A. G. Menskovsky, Y. P. Nikitin, and V. A. Shebanov, Phys. Letters **6**, 279 (1963); E. Shibata and M. Wahlig, *ibid.* **22**, 354 (1966). Baglin *et al.* and V. V. Barmin *et al.*, as reported by G. Goldhaber, in *Proceedings of the XIIIth International Conference on High Energy Physics* Berkeley, *California, 1966* (University of California Press, Berkeley, California, 1967).