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This letter contains the results of measurements of differential cross sections taken in the energy region of the second and third peaks of the π^--p total scattering cross section.[1, 2] The data were obtained by using an array of recoil proton scintillation counters in coincidence with pion detectors to identify elastic events. Details of the experimental procedure and the data analysis will be published separately.[3]

It should be here stated that we were unable to arrive at an independent normalization for the data, because of pion beam monitoring difficulties, although the shapes of the curves were rather well determined and repeatable. Therefore we normalized our data to the total elastic cross sections as determined by other workers and summarized by Falk-Vairant,[4] keeping the point at $\cos\theta^* = 1$ fixed at the value determined by dispersion relations[5] and the optical theorem (where θ^* is the c.m. scattering angle for the pion). Hence, the normalization is known only to about ± 12 to 15%. A future run is planned to measure the absolute normalization.

The errors quoted were obtained from a statistical analysis of the repeatability of repeated runs. The only region of the curve where the errors are significantly different from pure statistics (i.e., different by more than a factor of two) is that in which the recoil proton had nearly the same laboratory-system angle as the scattered pion. Corrections due to accidental and inelastic counts were 2% or less for all channels and all energies.

The results are listed in Table I, where θ^* is the center-of-mass angle of the scattered pion and $\frac{d\sigma}{d\Omega}$ is the differential cross section (in mb/...). The corresponding graphs appear in Fig. 1.

In Fig. 2 we present a plot of the energy dependence of the coefficients of the various cosine power series adjusted to our data, and also to the data of Goodwin et al.,[6] Shonle,[7] Bergia et al.,[8] and Chrétien et al.[9] The initials standing by the data points indicate their origins. From this behavior of the coefficients we make the following inferences.

1. The prominence of a_3 between 300 and 550 Mev may be ascribed to P-D interference. If so, it may be due to the overlap of the high-energy tail of the 200-Mev $P_{3/2}$ resonance with a D-state interaction building up with increasing energy.

2. The small magnitudes of a_3 and a_4 at 600 Mev indicate that if a D-state interaction exists at 600 Mev it has angular momentum 3/2. If at 600 Mev no states higher than $D_{3/2}$ interact strongly, and if the $P_{3/2}$ interaction has sufficiently decreased, we can understand the small $\cos^3\theta$ and $\cos^4\theta$ contributions and the prominence of a_2; a superposition of principally $S_{1/2}$ and $D_{3/2}$ waves would give just this.

3. At 900 Mev we require strong values of a_3, a_4, and a_5; but no powers higher than $\cos^5\theta$ are required to fit the data. These facts call for a prominent $F_{5/2}$ interaction together with strong D-state interaction. We cannot fit the 900-Mev data without a superposition of F and D waves (and possibly of P waves as well). The hump in the vicinity of $\cos\theta^* = -0.8$, which appears to be at a maximum at 900 Mev, is due to D and F (and possibly also P) spin-flip amplitudes in superposition.

4. The strong forward peaking, particularly at 900 Mev, implies that absorptive processes may be prominent in these "resonances." At 900 Mev a simple diffraction model with an absorbing volume whose radius is 1.2 fermis can describe quite well the small-angle data.

More extensive analysis of these results is in progress, including phase-shift calculations, and further experimental work is planned, including polarization measurements. In agreement with the assignments of Peierls,[10] we infer strong $D_{3/2}$ interaction at 600 Mev, and strong $F_{5/2}$ interaction at 900 Mev; but our data indicate a more complicated picture than simple resonances in these states.

We gratefully acknowledge our indebtedness to Professor A. C. Helmholz for encouragement and discussion, to Richard Eandi, Donald Hagge, and Dale Dickinson for their valuable assistance in all phases of the experiment, and to the Bevatron staff and crew.

REFERENCES

1. J. C. Brisson, J. Detoef, P. Falk-Vairant, L. Van Rossum, G. Vallada.. and L. C. L. Yuan, Phys. Rev. Letters 3, 561 (1959). (Also see their report at the 1960 Rochester Conference on High Energy Physics.

2. T. J. Devlin, B. C. Barish, W. N. Hess, V. Perez-Mendez, and J. Solom.., Phys. Rev. Letters 4, 242 (1960).

3. C. D. Wood, T. J. Devlin, J. A. Helland, M. J. Longo, B. J. Moyer, and V. Perez-Mendez, π^--p Elastic Scattering at 550, 600, 720, 900, an. 1020 Mev, to be submitted to Phys. Rev.

4. P. Falk-Vairant and G. Valladas; in Proceedings of the 1960 Rochester Conference on High-Energy Physics, (Interscience Publishers, Inc., New York, 1960), p. 38

5. J. W. Cronin; Phys. Rev. 118, 824 (1960).

6. L. K. Goodwin, R. W. Kenney, and V. Perez-Mendez, Phys. Rev. Letters .. 522 (1959); also The Elastic Scattering of Negative Pions by Protons at 230, 290, 370, and 427 Mev, Phys. Rev. (in press).

7. J. I. Shonle, Phys. Rev. Letters 5, 156 (1960).

8. S. Bergia, L. Bertocchi, V. Borelli, G. Brautti, L. Chersovani, L. Lavatelli, A. Minguzzi-Ranzi, R. Tosi, P. Waloschek, and V. Zoboli, Nuovo cimento 15, 551 (1960).

9. M. Chrétien, J. Leitner, N. P. Samios, M. Schwarz, and J. Steinberger, Phys. Rev. 108, 383 (1957).

10. R. F. Peierls, Phys. Rev. 118, 325 (1960).

[illegible] Angular distributions from $\pi^- + p \rightarrow \pi^- + p$. The normalization of the curves is known only to about 12 to 15% (see text for explanation)

[illegible] = 550 Mev		E = 600 Mev		E = 720 Mev		E = 900 Mev		E = 1020 Mev	
[illegible] θ^*	$d\sigma/d\Omega^*$ (mb/sr)	cos θ^*	$d\sigma/d\Omega^*$ (mb/sr)	cos θ^*	$d\sigma/d\Omega^*$ (mb/sr)	cos θ^*	$d\sigma/d\Omega^*$ (mb/sr)	cos θ^*	$d\sigma/d\Omega^*$ (mb/sr)
[illegible]	4.[illegible]±.24	1.0	6.19±.21	1.0	5.46±.24	1.0	17.82±.56	1.0	12.91±.40
[illegible]2101	2.63±.14	0.60793	2.69±.05	0.57743	1.44±.032	0.78163	3.92±.050	0.76638	3.00±.064
[illegible]215	2.16±.08	0.52725	2.29±.035	0.49242	1.17±.034	0.53391	0.405±.017	0.50618	0.345±.019
[illegible]735	1.74±.16	0.35918	1.54±.27	0.31764	0.86±.22	0.44323	0.203±.027	0.41215	0.200±.034
[illegible]849	1.16±.20	0.14816	0.79±.11	0.10192	0.717±.095	0.25983	0.218±.063	0.22410	0.204±.046
[illegible]705	0.577±.040	0.00611	0.332±.021	-0.04083	0.302±.017	0.03926	0.273±.026	0.00122	0.365±.025
[illegible]713	0.302±.028	-0.12776	0.167±.013	-0.17365	0.308±.014	-0.10349	0.351±.022	-0.14090	0.351±.035
[illegible]919	0.172±.028	-0.26858	0.124±.013	-0.31167	0.438±.034	-0.23412	0.461±.019	-0.26976	0.392±.022
[illegible]057	0.230±.023	-0.46716	0.254±.017	-0.50302	0.780±.029	-0.36731	0.726±.022	-0.39987	0.441±.026
[illegible]926	0.730±.043	-0.68059	0.674±.023	-0.70500	1.13±.023	-0.54859	1.409±.031	-0.57458	0.745±.050
[illegible]715	1.13±.05	-0.79494	0.911±.030	-0.81157	1.09±.027	-0.73539	2.069±.034	-0.75230	1.102±.044
[illegible]37572	1.41±.06	-0.88048	1.20±.046	-0.89061	0.985±.042	-0.83206	2.019±.044	-0.84339	1.030±.043
[illegible]625	1.53±.15	-0.94838	1.27±.055	-0.95288	0.550±.068	-0.90296	1.635±.046	-0.90974	0.792±.043
						-0.95837	0.790±.049	-0.96136	0.297±.041

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Fig. 1. Angular distributions from $\pi^- + p \to \pi^- + p$. θ^* is the angle by wh[ich] the pion is scattered in the c.m. system. The solid curves were ob[tained] from a least-squares fit of a cosine power series to the data.

Fig. 2. Coefficients a_ℓ from the expansion $d\sigma/d\Omega^* = \sum_{\ell=0}^{\ell_{max}} a_\ell \cos^\ell \theta^*$ which was fitted to the data by the method of least squares.

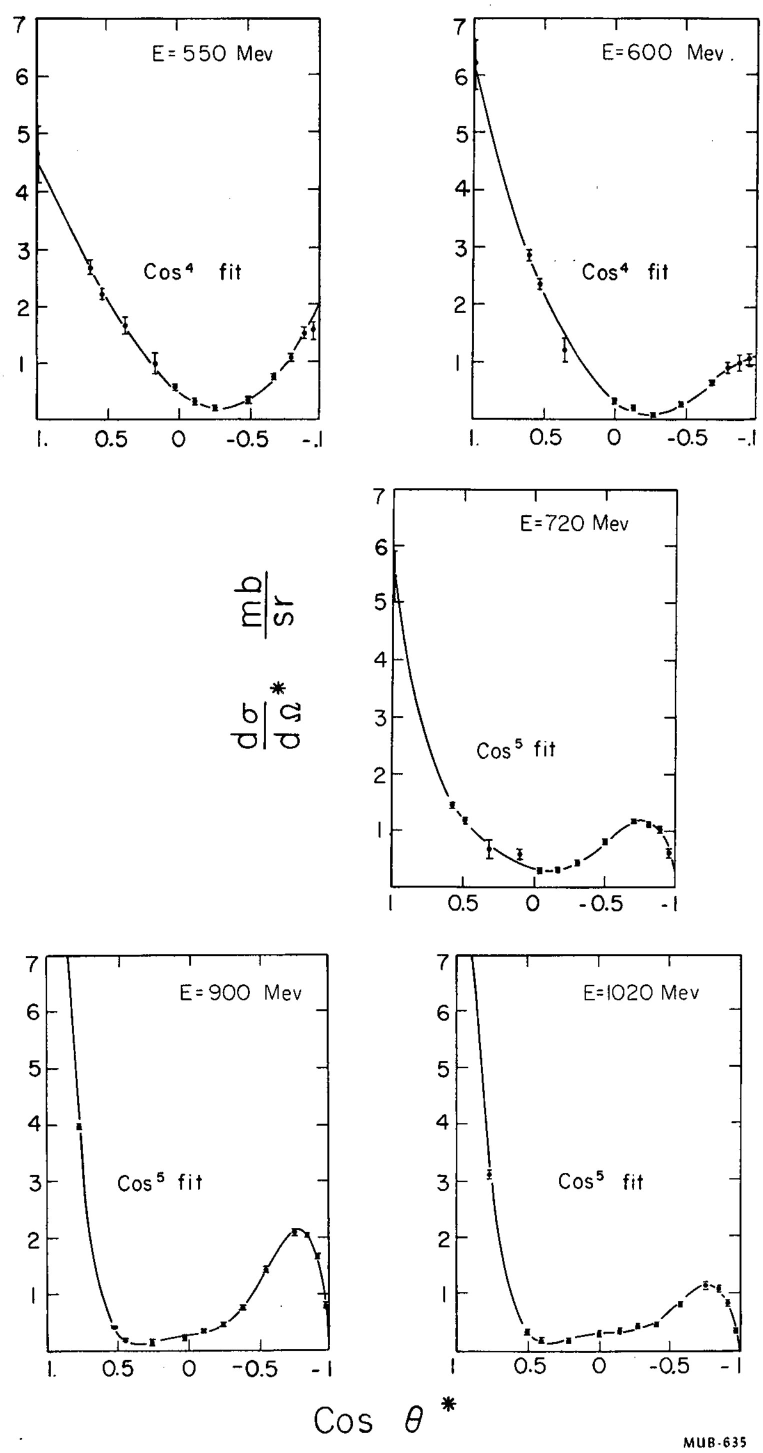
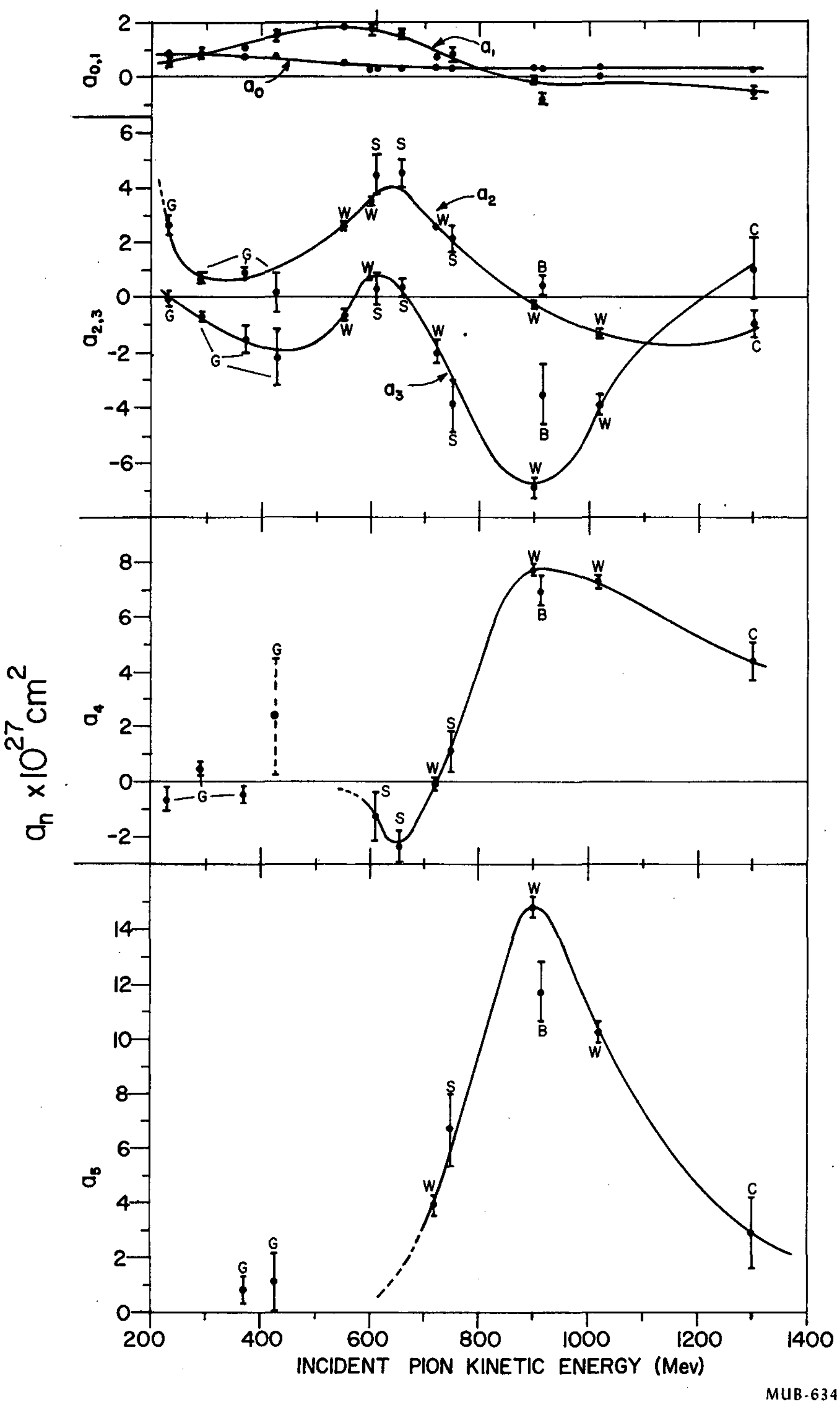


Fig. 1. Angular distributions from $\pi^- + p \rightarrow \pi^- + p$. θ^* is the angle by which the pion is scattered in the c. m. system. The solid curves were obtained from a least-squares fit of a cosine power series to the data.



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