$\pi^- - p^-$-CHARGE EXCHANGE SCATTERING BETWEEN 500 AND 1150 MeV

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We report here on an experiment performed at the Cosmotron to measure total cross-sections and angular distributions in the charge exchange reaction

$$\pi^- + p \rightarrow \pi^0 + n.$$

The experiment was done at eleven energies between 500 and 1150 MeV incident pion kinetic energy, using a spark chamber and counter array surrounding a liquid hydrogen target. The system subtended a total solid angle of (2/3) (4π).

The analysis, which has been previously described [1], is based upon the very characteristic peaked distribution exhibited by the opening angle θ, between pairs of gamma rays in the $\pi^- p$ center of mass system. This distribution exhibits a minimum opening angle θ_π which is a function of the mass and energy of the parent particle. Contamination of the charge exchange sample by η° and by multiple π° events has been minimized by choosing a small opening angle interval, including θ_π.

A Monte-Carlo calculation was used to determine the detection efficiencies of gamma rays arising from η°, π°, $2\pi^\circ$ and $3\pi^\circ$ mesons. Least squares fits were made using these effi-

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Charge exchange differential cross section $\left(\frac{d\sigma}{d\Omega} = \sum_l A_l \cos^l \theta\pi\right)$

$T\pi$ (MeV)	σT (mb/st)	A_0	A_1	A_2	A_3	A_4	A_5
545	6,97±.42	0,218±.034	0,395±.093	0,320±.245	0,907±.161	1,152±.302	
588	6,97±.40	0,182±.018	0,407±.046	0,437±.138	0,852±.083	1,136±.169	
619	6,78±.39	0,182±.025	0,402±0.60	0,744±.184	0,581±.101	0,546±.216	
659	5,54±.32	0,163±.021	0,496±.102	0,750±.162	−0,736±.466	0,139±.190	0,980±.433
755	4,28±.25	0,086±.022	0,318±.109	0,679±.196	−3,088±.527	0,140±.231	3,465±.507
827	6,07±.38	0,101±.025	0,546±.107	0,794±.226	−5,342±.535	0,586±.246	6,294±.516
878	6,77±.40	0,102±.036	1,015±.186	0,776±.330	−7,524±.948	0,888±.393	8,329±.921
916	5,88±.34	0,133±.023	0,945±.108	0,215±.207	−6,071±.557	1,317±.247	6,442±.546
1003	3,17±.18	0,145±.017	0,792±.081	0,113±.134	−3,942±.369	0,348±.158	3,686±.347
1151	2,03±.12	0,094±.016	0,208±.078	0,162±.121	−0,747±.346	0,068±.143	0,627±.319

ciencies along with the observed sample of 2 to 6 γ-ray events to determine the number of parent η°, η°, 2π° and 3π° events in the sample. The Monte-Carlo calculation also gives as estimate of the multiple π° events contaminating the charge exchange sample.

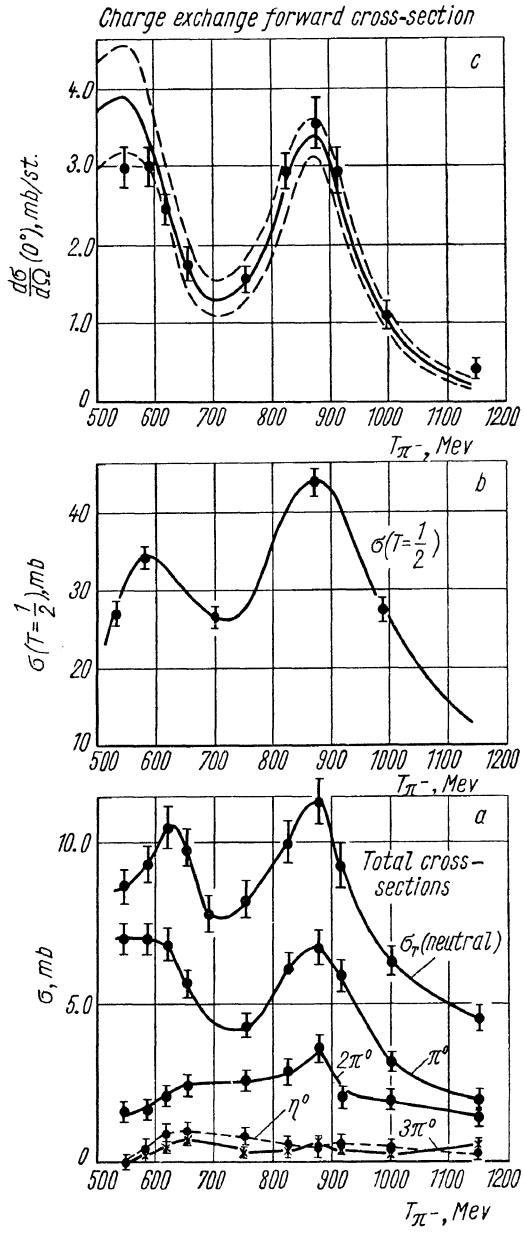

Fig. 1.

The total cross-section σ_T (neutrals) for all neutral processes as determined from the counting rates and the picture scan appears in Fig. 1a. The total cross sections for charge exchange scattering, 2π° and 3π° production and η° (→ 2γ) production, as determined by the calculation from the parent numbers are also plotted. These cross sections include corrections for a μ^- beam contamination of 2% and a e^- beam contamination which varied from (18 ± 4)% at the low energies to (7 ± 4)% at the higher energies. Using this charge exchange cross section and the data of Helland et al. [2], for the elastic $\pi^- p$ and $\pi^+ p$ scattering cross sections, one obtains the pure $T = 1/2$ elastic cross section. This is shown in Figure 1b and is in substantial agreement with the Saclay results [3].

For the charge exchange angular distribution, since we do not determine the energies of the observed gamma rays, the direction of the parent π° which gives rise to each 2-gamma ray event cannot be obtained unambiguously. However, the distribution of the bisectors of the two gammas can be related uniquely to the π° distribution. Least squares fits to the bisector distribution were made directly in terms of the π° angular distribution expressed as a cosine series.

The bisector distributions, corrected for detection efficiency are illustrated in Fig. 2. along with the smooth curve which in each case corresponds to the selected fit at that energy.

The coefficients of the cosine expansion for the π° are given in Table and illustrated in Fig. 3. In the vicinity of the second pion-nucleon resonance the coefficients exhibit no structure, whereas in the region of the third (900 MeV) resonance there are large, more or less equal and opposite contributions from A_3 and A_5. This is characteristic of a strong $D_{5/2}$—$F_{5/2}$ interference, which has also been observed in elastic scattering at this energy.

Using this data and that of Helland et al. [2] for the elastic scattering cross-sections at the maximum of the 900 MeV resonance, the angular distribution expansion for the $T = 1/2$ state is calculated to be:

$$\frac{d\sigma}{d\Omega}\left(T=\frac{1}{2}\right) = [(.50 \pm .09) + (2{,}05 \pm 1{,}06)x^2 + (9{,}49 \pm 3{,}02)x^4 + (2{,}97 \pm 2{,}57)x^6] + [(0{,}40 \pm .38)x - (20{,}95 \pm 2{,}03)x^3 + (33{,}58 \pm 2{,}82)x^5 + (1{,}65 \pm 1{,}31)x^7].$$

For a pure $D_{5/2} - F_{5/2}$ interference the angular distribution is:

$$\frac{d\sigma}{d\Omega}\left(T=\frac{1}{2}\right) = (D_{5/2}^2 + F_{5/2}^2)(1 - 2x^2 + 5x^4) + 2\mathrm{Re}\,(D_{5/2}F_{5/2}^*)(5x - 26x^3 + 25x^5).$$

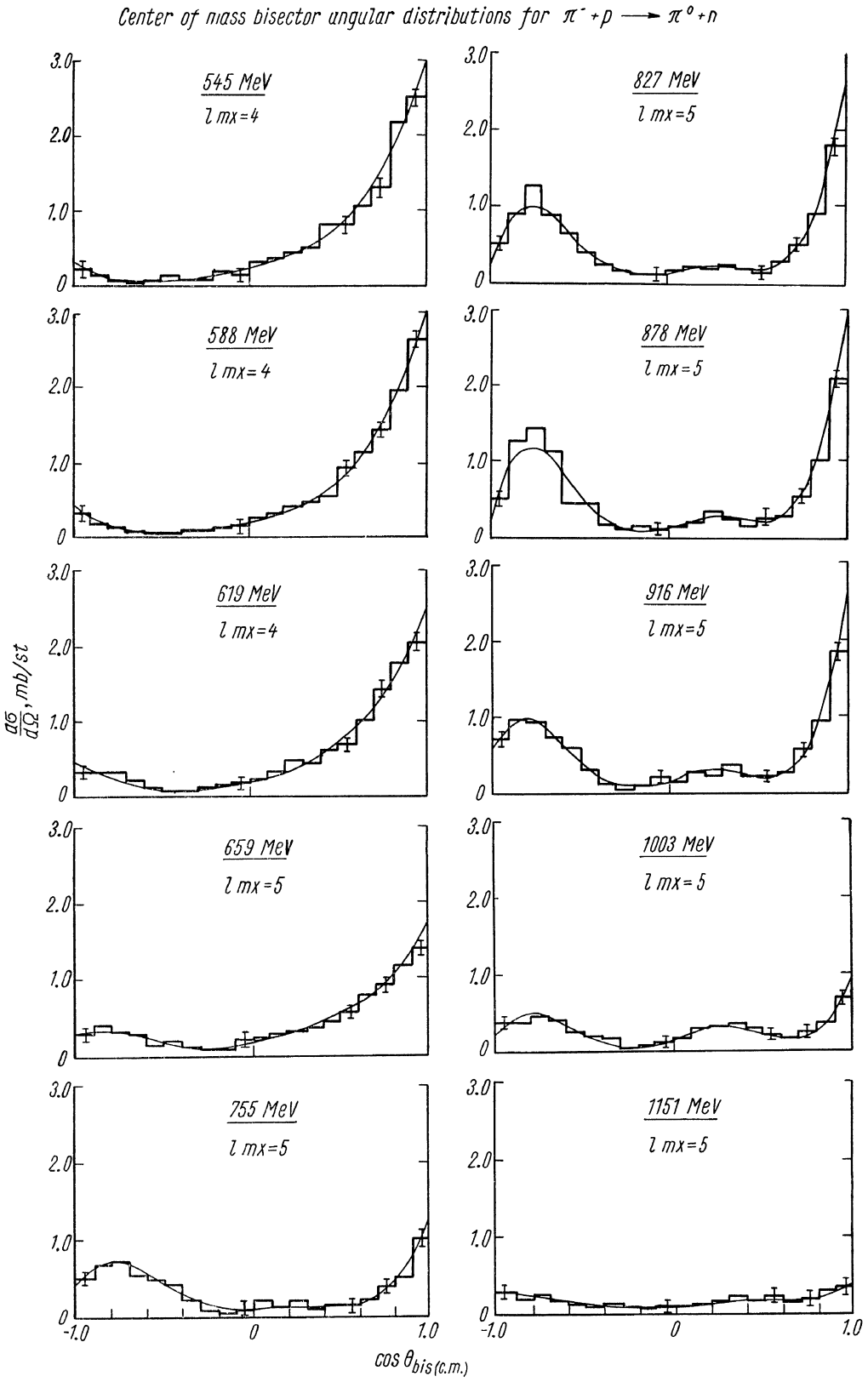
Center of mass bisector angular distributions for $\pi^- + p \longrightarrow \pi^0 + n$
545 MeV
l mx=4
827 MeV
l mx=5
588 MeV
l mx=4
878 MeV
l mx=5
619 MeV
l mx=4
916 MeV
l mx=5
659 MeV
l mx=5
1003 MeV
l mx=5
755 MeV
l mx=5
1151 MeV
l mx=5
$\frac{d\sigma}{d\Omega}$, mb/st
$\cos\theta_{bis(c.m.)}$

Fig. 2.

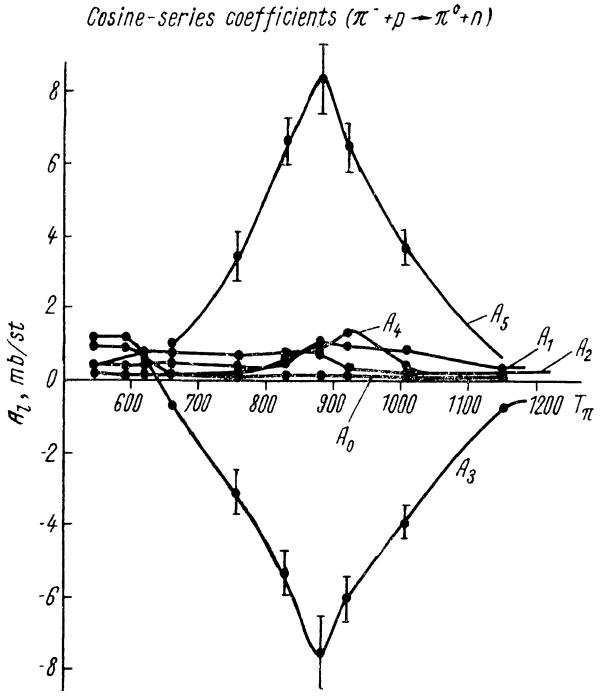

Fig. 3

The agreement is seen to be quite good and we conclude the $T = 1/2$ cross-section also exhibits a strong $D_{5/2}$— $F_{5/2}$ interference. Extrapolating our fitted π° angular distribution curves to zero degrees, we obtain the forward charge exchange scattering cross-section. These are plotted in Fig. 1c along with the predictions [4] from dispersion relations based on recent Saclay data [5]. It is evident that our experimental results exhibit the general features of these predictions.

REFERENCES

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