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SPIN-SPIN CORRELATIONS AND SPIN-ASYMMETRIES FOR THE REACTION $\vec{p}\vec{p} \rightarrow pn\pi^+$ AT INTERMEDIATE ENERGIES*

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Spin-spin correlation parameters A_{LL}, A_{NN}, A_{SS}, A_{SL} and spin-asymmetries A_{NO} and A_{ON} have been measured for the reaction $\vec{p}\vec{p} \rightarrow pn\pi^+$ with incident beam energies of 510, 465 and 420 MeV. Clean separation of free-proton events from the carbon background has been achieved. Results are compared with the predictions of Dubach, Kloet and Silbar.

1. INTRODUCTION

The BASQUE group has recently completed measurements of the spin-spin correlation parameters A_{LL}, A_{NN}, A_{SS}, A_{SL} and spin-asymmetries A_{NO} and A_{ON} in the reaction $\vec{p}\vec{p} \rightarrow pn\pi^+$ using the polarized beam and polarized proton target available at TRIUMF. In our notation for the correlation parameters, the first subscript refers to beam polarization, the second to target polarization, and the sign convention is shown in Figure 1. A_{NO} and A_{ON} are the spin-asymmetries observed by flipping the beam and target spins (N-direction), respectively. Measurements were made at three energies: approximately 510, 465 and 420 MeV at target centre.

2. EXPERIMENTAL PROCEDURE

The experimental layout is described fully in Ref. 1. Both outgoing charged particles were detected in one forward and two lateral arrays of multiwire proportional chambers (MWPCs). The angular acceptances were typically ±23° and ±12° (vertically and horizontally) for the large forward and smaller lateral arrays respectively.

A position-sensitive neutron detector subtended an angle of ±4.5° at 6m and was moved to cover all allowed neutron polar angles.

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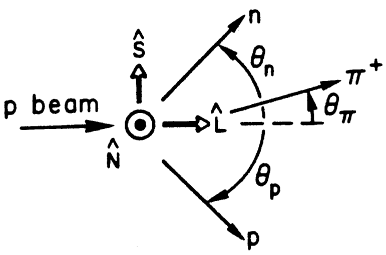

FIGURE 1
Convention used for spin directions and scattering angles.

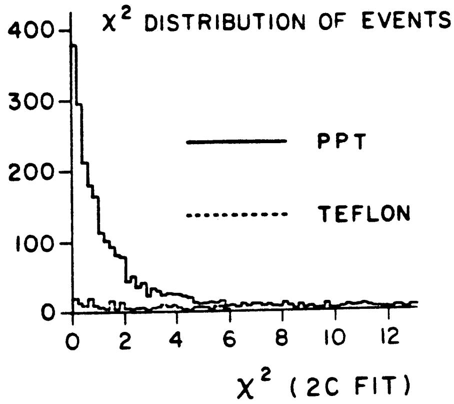

FIGURE 2
χ^2 distribution of reconstructed events with a polarized proton target and a teflon target in the A_{NN} configuration with a 470 MeV incident beam and the neutron detector at 8°.

The directions of all three particles were measured, as was the time of flight of the neutron. In principle these seven quantities would have overconstrained the event, but for the need to distinguish the proton from the pion, and to discriminate against the background from the non-hydrogenous material in the polarized target.

3. ANALYSIS

Each event was fully reconstructed kinematically as described in Ref. 1. The five equations of motion (three of momentum conservation, one of energy conservation, and one of measured neutron time of flight) were solved for the three out-going particle momenta assuming the struck proton was stationary. The χ^2 for the fit was used to select free proton events from the bound-proton background. Figure 2 compares the χ^2 distribution for the polarized proton target and that for a run with a teflon target (chosen to simulate non-hydrogenous material in the polarized target). In this case the cut was made at $\chi^2 = 3$, leaving a contamination of approximately 10%, for which the measured asymmetries were corrected.

4. RESULTS

Results are presented for events at 510 MeV beam energy binned in various ways. The errors shown are statistical, but for A_{LL}, A_{SL} and A_{SS} there is an additional scale uncertainty of approximately 10% arising from the calibration of beam and target polarizations.

Initially the data were binned according to charged particle angle pairs and proton momenta to allow direct comparison with the existing model of Dubach et al.[3,4] This is a relativistic, unitary isobar model involving only one-pion exchange, P_{11} and P_{33} πN final states and without dibaryon resonances. Two such cases are shown in Figures 3 and 4. The broad agreement with the model is typical of all our data, although A_{LL}, A_{NN} and A_{SS} are generally smaller in magnitude than predicted. This feature is also seen in the Geneva-SIN $\vec{p}\vec{p} \rightarrow d\pi^+$ data[5].

In order to discover the kinematic dependences of the asymmetries the data has been binned in a series of one-dimensional plots against many variables, some in the centre-of-mass frame and the delta rest frame. A selection is shown in Figures 5-8. The Gottfried-Jackson and Triemann-Yang angles (θ_{GJ} and ϕ_{TY}) are the polar and azimuthal angles of the pion in the delta rest frame (with respect to the beam direction and the $NN \rightarrow N\Delta$ scattering plane).

Conclusions drawn from the results are as follows. Firstly, over large areas of phase-space $A_{NN} \approx A_{LL} \approx A_{SS} \approx -1+\varepsilon$ and $A_{SL} \approx 0$. This indicates that the contribution of the $^1D_2$ is large, and increases as the $p\pi$ invariant mass approaches that of the Δ (Figures 5 and 6). ε is larger than model predictions. Secondly, $A_{NO} \approx -A_{ON}$ and $|A_{NO}|>|A_{ON}|$ (as predicted by the model[4]), both suggesting a linear dependence on the transverse neutron momentum and $\cos\phi_{TY}$ (Figures 7 and 8). The observed asymmetries are larger than predicted, which may be due to contributions by ρ-exchange. Both these observations also apply to the Geneva-SIN $\vec{p}\vec{p} \rightarrow d\pi^+$ data[5] except that they find $A_{SL} \approx -0.5$ over much of their acceptance.

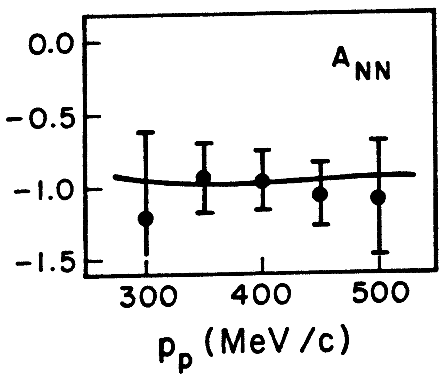

FIGURE 3
A_{NN} at 510 MeV for coplanar events: θ_p=10°±6°, θ_π=21°±4° plotted against outgoing proton momentum. Solid line is a calculation of Dubach et al. for θ_p=10°, θ_π=20° at 500 MeV.

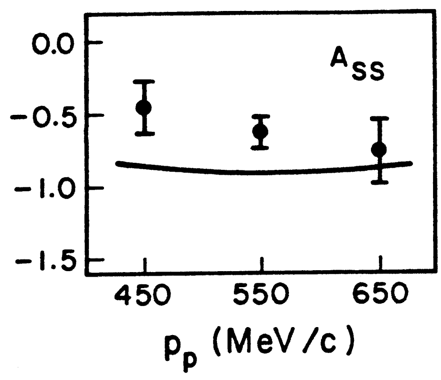

FIGURE 4
A_{SS} at 510 MeV for coplanar events: θ_p=10°±2°, θ_π=85°±12° plotted against outgoing proton momentum. Solid line is a calculation of Dubach et al. for θ_p=10°, θ_π=80° at 500 MeV.

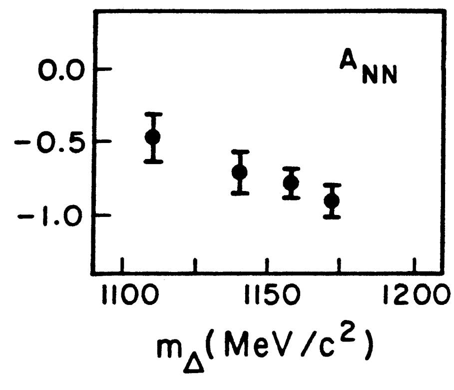

FIGURE 5

A_{NN} at 510 MeV, all events with p,π in forward array, plotted against pπ invariant mass, m_{Δ}.

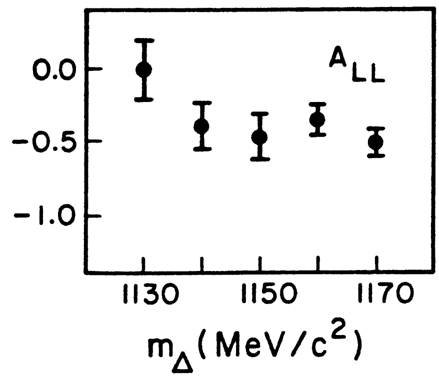

FIGURE 6

A_{LL} at 510 MeV, all events with p in forward array, π in lateral array, plotted against pπ invariant mass, m_{Δ}.

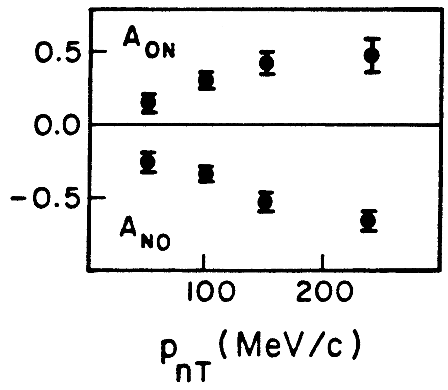

FIGURE 7

A_{NO} and A_{ON} at 510 MeV, all events with p,π in forward array, plotted against transverse neutron momentum.

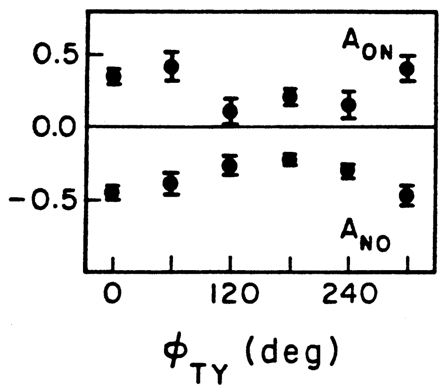

FIGURE 8

A_{NO} and A_{ON} at 510 MeV, all events with p,π in forward array, plotted against the Triemann-Yang angle.

Work on this data is proceeding toward a more complete kinematical analysis.

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