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SPIN-SPIN CORRELATIONS IN THE REACTION $\vec{p}\vec{p} \rightarrow pn\pi^+$ AT INTERMEDIATE ENERGIES

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Abstract

Spin-spin correlation parameters A_{LL}, A_{SL}, A_{NN}, A_{SS} and P 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 agree well with the predictions of Dubach, Kloet and Silbar.

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Structure first observed at Argonne in proton-proton total cross-section differences $\Delta\sigma_L$ and $\Delta\sigma_T$ [1-3] has now been qualitatively confirmed by a series of experiments at TRIUMF [4], SIN [5] and LAMPF [6]. The original hypothesis that the structure was due to resonances in the $^1D_2$, $^3F_3$ and $^1G_4$ partial waves [7] has not been confirmed. If the $^1D_2$ dibaryon exists it should have a branching ratio to NΔ of greater than 70% [7]; therefore further information should be accessible by studying the spin dependence of $\vec{p}\vec{p} \rightarrow pn\pi^+$ in the framework of the NN $\rightarrow$ NΔ model. Such an analysis may show whether the structure is indeed due to a dibaryon resonance or to effects of the onset of inelasticities in successive partial waves [8].

The BASQUE group has recently completed measurements of the spin-spin correlation parameters A_{LL}, A_{SL}, A_{NN}, A_{SS} and P in the reaction $\vec{p}\vec{p} \rightarrow pn\pi^+$ using the polarized beam and polarized proton target available at TRIUMF. In our notation, the first subscript refers to target polarization, the second to beam polarization, and the sign convention is shown in fig. 1. Measurements were made at three energies: approximately 510, 465 and 420 MeV at target centre, although only 510 MeV data for A_{LL}, A_{NN}, A_{SS} and P at forward angles are reported here.

The experimental layout is shown in fig. 1. The combination of solenoids and bending magnet in the beam line and movable Helmholtz coils in the target made all desired combinations of spin directions accessible. The beam intensity was typically $2 \times 10^6\ s^{-1}$. The target was a 15 mm diameter, 25 mm long cylinder and its composition by weight was 95% $C_4H_{10}O$ with Cr^V-EHBA dopant, and 5% H_2O. The beam and target polarizations averaged about 0.7 and 0.65, respectively.

Both outgoing charged particles were detected in arrays of multiwire proportional chambers (MWPCs); a large forward array with six wire planes and two smaller lateral arrays with four planes each. The angular acceptance of these arrays is given in table 1.

The position-sensitive neutron detector N, which like the forward MWPC array was that used in the previous N-N elastic scattering programme [9], subtended an angle of ±4.5° at 6 m and was moved to cover all allowed neutron polar angles. Charged particles were rejected by the veto scintillator NV.

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.

Events were analysed assuming that the struck proton was stationary, and finding the values of the three outgoing momenta which best fitted the five kinematic equations (three of momentum conservation, one of energy conservation, and the measured neutron time of flight). Initial estimates of momenta were obtained on the basis of measured (asymptotic) tracks and then a first estimate of the bend angle in the magnetic field of the target was made. Final values for the momenta and actual scattering angles were obtained iteratively.

Charged particle assignments were made by selecting the combination with the lower value of χ^2 for the fit. A cut was then applied on χ^2 to separate the $pp \rightarrow pn\pi^+$ events involving a free proton from those involving a bound proton or from other reactions giving rise to a trigger.
In fig. 2 events taken with the polarized target are compared with those from a teflon target (to simulate non-hydrogenous material in the

polarized target and of the same thickness), after normalization at high χ^2. For this configuration (A_{NN}), a cut was made at $\chi^2 = 3$ to minimize the contribution of the background to the free-proton signal. A contamination of approximately 10% bound-proton events remained and the measured asymmetries have been adjusted accordingly. No peak appears in the background distribution at low χ^2. No data were taken with a teflon target at 510 MeV. To estimate the contamination at this energy the background shape was assumed to be independent of energy, and normalization was carried out by fitting to the tail of the polarized target distribution.

Results for a selection of near-coplanar events at 510 MeV beam energy are shown in fig. 3. These are compared with the model of Dubach et al. [10,11]. This is a relativistic, unitary isobar model involving only one-pion exchange, P_{11} and P_{33} πN final states and without dibaryon resonances. The polarization parameter P is therefore zero to first order. The measured coefficients show broad agreement with the model.

The whole body of data, of which that selected for display in fig. 3 is a small fraction, is currently being analysed.

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Table 1

Angular acceptance for various spin configurations.

Spin Configuration	Angular Acceptance: Forward Chambers Horizontal	Forward Chambers Vertical	Side Chambers Horizontal	Side Chambers Vertical
A_{SL}, A_{LL}	±23°	±23°	±12°	±12°
A_{NN}	26°left,20°right	±7.5°	-	-
A_{SS}	±12.5°	26°up,20°down	±12°	±12°

Figure captions

1. Experimental configuration. V is a counter with a 1 cm hole at the centre. T_1 and T_2 monitor incident beam intensity and M_1 and M_2 monitor beam intensity on the target. L_1 and L_2 are single scintillators which trigger the lateral MWPC arrays. F is a hodoscope which triggers the forward MWPC array. (Not to scale.)

2. Comparison of the χ^2 distribution of reconstructed events with a polarized proton target and a teflon target in the A_{NN} configuration with a 465 MeV incident beam and the neutron detector at 8°.

3. Spin-spin correlation parameters for $\vec{p}\vec{p} \to pn\pi^+$ as a function of scattered proton momentum at 510 MeV with the neutron detector at 8°. Near-coplanar events with $\theta_p = 10°±5°$, $\theta_\pi = 20°±5°$ (except for A_{SS} with $\theta_p, \theta_\pi = 0°±12.5°$). Vertical acceptance of p,π is ±7.5° (±23° for A_{LL}). Points are present data, for which there is a scale uncertainty of 10% arising from the calibration of target polarization. Bin widths are 50 MeV/c (100 MeV/c for A_{SS}). Solid lines are calculations from [11] with $\theta_p = 10°$, $\theta_\pi = 20°$ at 500 MeV.