Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 984-985

5.16 Spin Alignment of ρ^0-mesons in Charged Current Antineutrino Interactions

V.V. Ammosov, A.E. Asratyan+, V.S. Burtovoy, A.G. Denisov, A.V. Fadotov+, V.A. Gapienko, G.S. Gapienko, P.A. Gorichev+, V.I. Klukhin, V.I. Koreshev, S.P. Krutchinin+, M.A. Kubantsev+, I.V. Makhljueva+, P.V. Pitukhin, V.I. Shekelyan+, V.G. Shevchenko+, V.I. Sirotenko, E.A. Slobodyuk, Z.U. Usubov and V.G. Zaetz

Institute for High Energy Physics, Sepukhov, USSR
+Institute for Theoretical and Experimental Physics, Moscow, USSR

The results on studying the spin alignment (tensor polarization) of ρ^0-mesons produced in the quark jets of CC antineutrino interactions are presented in this paper. The investigation of spin alignment of ρ^0-mesons producėd in the process of quark fragmentation is the direct check of ρ^0-meson vector coupling with the fragmenting quarks (Fig. 1)[1-3]. This, in its turn, should reveal in the correlation of ρ^0-meson spin with its momentum transfer with respect to the direction of the fragmenting quark motion. The expected yeild for the diagrams of the type shown in Fig. 1 is $\rho^0/\pi^0 = 1$[3]. Experimenal data used in this paper were obtained with Fermi-lab 15-Ft. bubble chamber[4].

4.030 CC antineutrino events with the invariant mass of hadron W>2 GeV were selected to investigate the ρ^0-meson spin alignment, determined from the approximation of angular distributions of ρ^0-meson decay products using expression[5]:

$$dN/d(\cos\theta) \sim (3\rho_{00} - 1)\cos\theta + 1 - \rho_{00}, \qquad (1)$$

where θ is a polar angle between the direction of π^+-meson momentum from $\rho^0\to\pi^+\pi^-$-decay and the axis $\hat{Z}$ in ρ^0-meson rest frame; ρ_{00} is a probability for ρ^0-meson to have a zero spin projection on the axis $\hat{Z}$. The analysis was performed in two orthogonal systems: i) in the helicity system, where the axis $\hat{Z}$ is the direction of ρ^0-meson momentum; ii) in the transversal system, where the axis $\hat{Z}$ is the direction of the normal with respect to the ρ^0-meson production plane: $\vec{n} = \vec{q}\times\vec{p}_{\rho^0}/|\vec{q}\times\vec{p}_{\rho^0}|$, where $\vec{q} = \vec{p}_\nu-\vec{p}_\mu$ is the vector of antineutrino-muon momentum transfer.

The angular distributions of ρ^0-meson decay products were reconstructed by approximating the $\pi^+\pi^-$ invariant mass (M) spectra:

$$dN/dM = BG(M)\cdot(1 + BW(M)) \qquad (2)$$

in various intervals of decay angles, where BW(M) is the Breit-Wigner function[6]; $BG(M) = C\cdot\exp(-\beta\cdot M)$ is the parametrization of the combinatorial background under the resonant signal; C, α and β are the fit parameters. The invariant mass spectra were approximated in the mass region of $0.56<M(\pi^+\pi^-)<1.16$ GeV at $z=E(\pi^+\pi^-)/(E_\nu-E_\mu)>0.4$.

Since it was impossible to identify π and K-mesons unambiguously in this experiment, the arbitrary assignment of masses to the tracks resulted in the K^{*0}-meson kinematic reflection in the $\pi^+\pi^-$ invariant mass spectrum. The contribution of K^{*0}-meson distorting the final result of ρ^0-meson spin alignment was checked using artificial events obtained with the LUND model[7]. Corrections for K^{*0}-meson reflection in the spectrum of $\pi^+\pi^-$ invariant masses were introduced by the method proposed by Barth et al.[8]

The angular distributions of ρ^0-meson decay products for the helicity system are presented in Figs. 2a-c. Analogous distributions for the transversal system are shown in Figs. 2d-f. In order to study a possible correlation of ρ^0-mesons and their momentum transfer with respect to the direction of the weak current the data were divided into two intervals, i.e. of small $p_\perp^2$ ($<0.2(\mathrm{GeV/c})^2$) and large $p_\perp^2$ (>0.2 $(\mathrm{GeV/c})^2$). The behaviour of the angular distributions of ρ^0-meson decay products is considerably different at small and large $p_\perp^2$ of ρ^0-mesons, which cannot be accounted for by the influence of combinatorial background under the resonant signal. Nor can it be explained by the influence of reflection from K^{*0}-mesons, since their bahaviour is weakly dependent on $p_\perp^2$. On the other hand, the observed behaviour of angular distribution of the ρ^0-meson decay products is in good agreement with the prediction[1-3]. The analysis of angular distributions of these products points that the ρ^0-meson spin does tend to be correlated with its transverse momentum. In this case ρ^0-mesons produced at small momentum transfers in the direction of the current are highly probable to have the zero spin projection ($\rho_{00}=0.73\pm0.16 > 1/3$) on their momentum direction and a small probability of the zero spin projection ($\rho_{00}=0.00\pm0.06$ $< 1/3$) on the direction of the normal to the ρ^0-meson production plane, respectively.

The behaviour of angular distributions of ρ^0-meson decay products in the region of $p_\perp^2 > 0.2$ $(\mathrm{GeV/c})^2$ indicates that the spin alignment of ρ^0-mesons possibly has an inverse sign with respect to the spin alignment of ρ^0-mesons produced with small $p_\perp^2$. However, as seen in Figs. 2b and 2e, angular distributions agree within the errors with the absence of ρ^0-mesons spin alignment at $p_\perp^2 > 0.2$ $(GeV/c)^2$. Figs. 2a and 2d presents angular distributions for whole $p_\perp^2$ interval.

Proceeding from the validity of the assumption that the suppression of the definite spin states of vector mesons must result in the decrease of the yield of V (vector meson)/PS (pseudoscalar meson) (equal to V/PS = 3 in the case of equally probable realization of all spin states), in our experiment one should evidently expect the ratio $\rho^0/\pi^0 < 3$. The yield of ρ^0/π^0 versus Z obtained in this experiment is presented in Fig. 3. To determine the differential distribution of π^0-mesons over z we used the isotopic relation

$$dN(\pi^\circ)/dz = (dN(\pi^-)/dz + dN(\pi^+)/dz)/2$$

Since the distributions of ρ^0 and π^0 -mesons are well described in the region of $z > 0.3$ by the exponential function, we used expression $A\cdot\exp(B\cdot z)$ to approximate ρ^0/π^0 vs z. The extrapolation for the values of z = 1 yielded $\rho^0/\pi^0 = 1.1\pm0.3$ for the directly produced mesons. The obtained value for V/PS does not exclude the possibility of ρ^0-meson production in the fragmentation processes with the nonzero spin alignment.

References

1) J.F. Donoghue: Phys. Rev. D17 (1978) 2922.
2) A.V. Efremov and O.V. Teryaev: Preprint JINR P2-82-832, 1982.
3) R. Suaya and J.S. Towsend: Phys. Rev. D19 (1979) 1414.
4) V.V. Ammosov et al.: Nucl. Phys. B199 (1982) 399.
5) K. Schilling and G. Wolf: Nucl. Phys. B61 (1973) 381.
6) J.D. Jackson: Nuovo Cim. 34 (1964) 1644. J. Pisut and M. Ross: Nucl. Phys. B6 (1968) 325.
7) T. Sjostrand: Comp. Phys. Comm. 27 (1982) 243.
8) M. Barth et al.: Nucl. Phys. B223 (1983) 296.

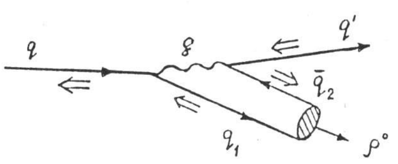

Fig. 1. The simpliest QCD-diagram for $q \to q'+\rho^\circ$ fragmentation.

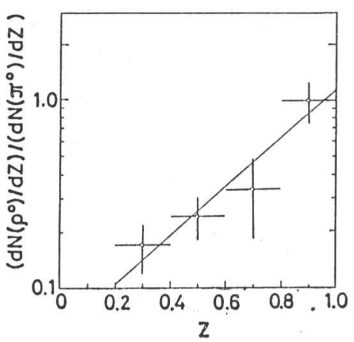

Fig. 3. The ratio $[dN(\rho^\circ)/dz]/[dN(\pi^\circ)/dz]$ vs z. The straight line shows the result of the approximation of the yield ρ°/π° vs z by the exponent with the parameters given in the text.

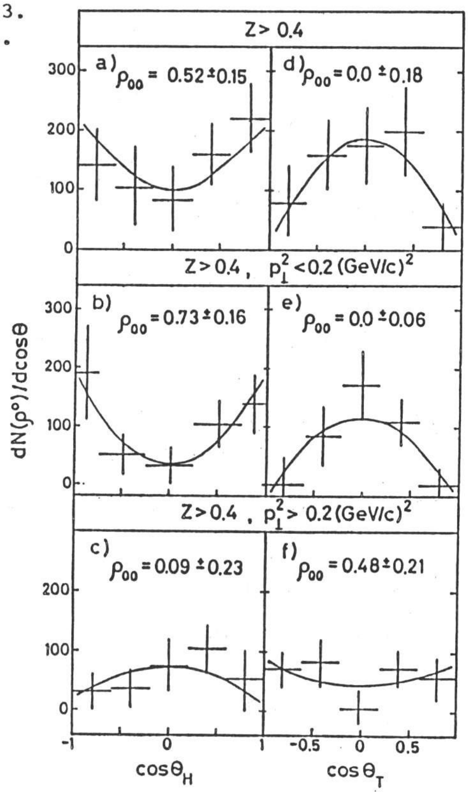

Fig. 2. Distributions over the cosine of the polar angle of π^+-mesons from the ρ°-meson decay, (a-c) in the helicity system, (d-f) in the transversal system, respectively.