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POLARIZATION OF Λ HYPERONS PRODUCED INCLUSIVELY IN νp AND $\bar{\nu} p$ CHARGED CURRENT INTERACTIONS

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ABSTRACT

Λ hyperons from νp and $\bar{\nu} p$ charged current interactions have been analysed for polarization. A significant polarization is observed for Λ particles in the quasi-elastic region for both types of interactions. Part of this polarization is due to the decay of highly polarized $\Sigma(1385)$ resonances. The results are compared with simple predictions of the quark parton model.

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1) Introduction

Experiments measuring the polarization of Λ hyperons produced in high energy hadronic interactions [1] have stimulated much theoretical interest in the spin dynamics of the strong interaction [2]. In this experiment, the availability of relatively large statistics in neutrino and antineutrino-proton interactions in BEBC filled with hydrogen [3], has now made it possible to search for polarization of inclusively produced Λ particles in weak interactions.

Earlier measurements of Λ polarization in ν and $\bar{\nu}$ interactions [4] have suffered from inconsistent results. For example, Ammosov et al. reported a small positive polarization normal to the plane defined by the $\bar{\nu}$ and the Λ direction in $\bar{\nu}\text{Ne}$ interactions while Allasia et al. found a small negative normal polarization in $\bar{\nu}\text{D}$ scattering. Berge et al. found no evidence for polarization in νp interactions though the statistics were limited.

Most current theoretical literature on polarization effects in weak interactions describes the polarization of particles produced in the fragmentation region of the struck quark (the current fragmentation region) at large W (the hadronic effective mass) and Q^2 (the square of the four-momentum transfer between the incoming and outgoing leptons) [5]. When quark masses can be neglected, the helicity state of the struck quark is unique, and particles which contain the struck quark may reflect its polarization. Unfortunately only a very small percentage of the produced Λ particles populate the current fragmentation region. Bigi [6] has shown however that in the region where the final state hadrons are fragments of the target remnant (the target fragmentation region, TFR), large Λ yields as well as large polarization effects can be expected. This is because in the standard V-A theory (again neglecting quark and lepton masses) the interaction of the weak charged current on quarks and antiquarks picks out only quarks with negative helicity and antiquarks with positive helicity (see Fig. 1). Then, since the target nucleon is initially unpolarized, the remnant system must carry some compensating polarization which may be carried through the fragmentation process to the final baryon.

This paper presents a measurement of the magnitude and direction of the Λ polarization in the TFR. The results are compared with the predictions of ref. [6].

2) Experimental Details

The data constitute charged current (CC) νp and $\bar{\nu} p$ interactions observed in BEBC filled with hydrogen and exposed to a two-horn focussed wide band (anti)neutrino beam produced by 350 and 400 GeV protons from the SPS at CERN. The CC event sample was selected according to the following criteria:

- a) Only events with a muon momentum greater than 3 GeV/c were accepted to ensure good acceptance of the two-plane external muon identifier (EMI). The EMI acceptance varied from 40% at 3 GeV/c to 98.5% above 10 GeV/c.
- b) A total visible energy of greater than 5 GeV was required for each event to reduce low energy background induced by neutral hadrons.

A total of 11344 CC νp events and 6222 CC $\bar{\nu} p$ events satisfied these cuts. The (anti)neutrino energy was determined by a method based on transverse momentum balance [7] which corrected for the presence of undetected neutral particles.

Charged two body decays of neutral particles for which the χ^2 probability for the kinematic fit to the Λ hypothesis was greater than 1% were kept as Λ candidates. The following selections were used to further purify the Λ sample:

- a) The Λ path length was required to be less than 6 mean decay lengths.
- b) The uncertainty in the Λ momentum had to be less than 6% which eliminated 3% of the Λ candidates from the νp and $\bar{\nu} p$ data samples.
- c) All candidates whose fit probabilities were greater than 10^{-4} for other decay hypotheses (i.e. K^0 or γ), were labelled as ambiguous. The Λ hypothesis was always chosen for the Λ/K ambiguities and the γ hypothesis was always chosen for the γ/Λ ambiguities.

Selection (c) was used because it was found from a previous

analysis [8] that the majority of the Λ/K ambiguous candidates were in fact Λ 's and that the γ interpretation should be chosen for the γ/Λ ambiguities. This resulted in a small ($\approx 3\%$) K^0 background, which was shown to have a negligible effect on the polarization. The effect of this background and other sources of spurious polarization signals (biases) on the polarization analysis will be discussed later. Due to the large γ conversion length in hydrogen, no attempt could be made to distinguish Λ 's coming from Σ^0 decay.

With these cuts applied to the total CC sample, 289 Λ 's from νp interactions and 267 Λ 's from $\bar{\nu} p$ interactions were found.

3) Polarization Analysis

For a sample of Λ hyperons with polarization $\vec{P}_\Lambda$ the theoretical decay angular distribution of the decay proton in the Λ rest frame is

$$\frac{dN}{d\cos\theta d\phi} = \frac{1}{4\pi} (1 + \alpha_\Lambda \vec{P}_\Lambda \cdot \hat{p}_p) \quad (1)$$

where $\alpha_\Lambda = 0.642 \pm 0.013$ is the Λ asymmetry parameter for the charged decay mode [9],

$\hat{p}_p$ = the decay proton direction in the Λ rest frame,

$\vec{P}_\Lambda$ = the Λ polarization vector,

θ, ϕ = the polar and azimuthal angle respectively of the decay proton with respect to $\vec{P}_\Lambda$.

In a given coordinate system in the Λ rest frame, the three components of $\vec{P}_\Lambda$ were simultaneously determined by fitting expression (1) to the experimental angular distribution of the decay proton with a maximum likelihood program. The precession of the Λ spin due to the interaction between the BEBC magnetic field and the Λ magnetic moment was also accounted for in the fit, but this affect was quite small since typical precession angles were less than 10° . The physically interesting directions in the Λ rest frame are the current direction $\hat{J}$, (the momentum transfer direction) and the target proton direction $\hat{P}$. (we use

the hat to signify unit vectors throughout the paper). These two vectors define the Λ -production plane. The perpendicular to this plane is defined as $\hat{J} \times \hat{P} / |\hat{J} \times \hat{P}|$. Using these vectors, the two coordinate systems used for the analysis were defined as:

$$\begin{aligned} \text{System "P", "J":} \quad & \hat{1} = \hat{P} \text{ or } \hat{J} \\ & \hat{2} = \hat{J} \times \hat{P} / |\hat{J} \times \hat{P}| \\ & \hat{3} = \hat{1} \times \hat{2} \end{aligned}$$

We shall call the two coordinate systems "P" or "J" depending on the choice of the first axis. Other coordinate systems were considered but yielded no additional information not contained in the two systems presented here.

4) Biases

Before discussing the results of this analysis, it is important to consider separately the sources of possible biases and their influence on the Λ polarization.

Biases can arise from losses in geometrical acceptance, scanning inefficiencies, uncertainties in estimating the (anti)neutrino energy and backgrounds. Each of these categories was investigated and the results indicated that biases produced from these effects were negligible compared to the statistical accuracy available.

Because of our 4π acceptance, biases due to geometrical losses were negligible. There were two sources of scanning inefficiency: a) inefficiency in finding primary vertices, and b) inefficiency in finding associated Λ 's.

The first inefficiency was confined to events with low charged hadron multiplicity, n_c . Independent scans have shown that for events with $n_c \geq 2$ the scanning efficiency was better than 97%. The class of $\bar{\nu}p$ events with $n_c = 0$ (called 1-prongs) had very poor scanning efficiency but was augmented by a special 1-prong scan utilizing the information from wire chamber detectors situated around BEBC to predict the event location [10]. As far as could be ascertained from the statistics available, the polarization showed no dependence on the method of scanning.

The second inefficiency is estimated to be small ($<5\%$) and confined to Λ 's which decay close to the primary vertex. Though this translates into a small, weakly momentum dependent loss due to the Lorentz effect, Monte Carlo calculations have shown that for our Λ momenta this loss can affect the asymmetry ($\alpha_{\Lambda} P_{\Lambda}$) by at most 0.01.

The uncertainty in the neutrino energy estimation affects the definition of the axes $\hat{P}$ and $\hat{J}$ and thus essentially the polarization direction, but also slightly the magnitude of the polarization due to the "smearing" of the axis definitions. Since the neutrino energy estimation is worst for low multiplicity events, they can serve as a sample to find the maximum effect. For this purpose all events of the type $\nu p \rightarrow \mu^{-} \Lambda h^{+} h^{+} X^0$ were treated as if the two positive hadrons (h^{+}) were not measured and then the Λ 's were analysed for polarization. The resulting angle through which the polarization vector rotated was 6° . This rotation is small compared to the statistical uncertainty in the polarization direction for that sample, which was $\pm 15^{\circ}$.

The largest systematic bias was found to be due to the 3% K^0 background stemming from the inclusion of all Λ/K ambiguities in the Λ sample. A 3% K^0 contamination however was found to affect the asymmetry $\alpha_{\Lambda} P_{\Lambda}$ by at most 0.03. This is also negligible compared to the statistical error and was therefore ignored in the final results.

The K^0 mesons in the data, being spinless and having the same decay topology as the Λ hyperons, presented an ideal data sample to test the claim that the polarization analysis was free of biases, by performing the analysis on the K^0 sample also. For this purpose all selection criteria for the K^0 candidates were the same as those used for the Λ candidates, except that Λ/K ambiguities were completely excluded. The polarization analysis was also identical except for precession effects. The asymmetry signals were all consistent with zero, as expected for an unbiased K^0 sample.

5) Results

The polarization results in the two coordinate systems "P" and "J" are tabulated in Table 1 for several different selection criteria. As can

be seen, the selections are based on the following quantities: W , Q^2 , x_B (Bjorken x_B), n_c , x_F (Feynman x_F of the Λ), and Δ (the absolute difference between the $\Sigma^*(1385)$ mass and the $\Lambda\pi^*$ invariant mass). It should be noticed that the table has been arranged so that two adjacent selections are complementary to each other. For example, cut 2 selects Λ 's going backward in the hadronic center of mass, whereas selection 3 is for forward going Λ 's. The polarization results in table 1 and their dependence on the various selection cuts will now be discussed.

The results for the polarization component perpendicular to the production plane, i.e. along $\hat{J} \times \hat{P}$ (the second component in Table 1), are shown in Fig. 2 for several selection cuts in system "P". The choice of coordinate system was arbitrary because the second component in the two systems for the same event sample are in excellent agreement, indicating that precession effects, which correlate the different polarization components, are small. The perpendicular component of the polarization is consistent with zero within 1.5σ in both νp and $\bar{\nu} p$ data for all selections. This result is in agreement with πp [11] data at a similar value of the center of mass energy ($\approx 5\text{GeV}$) where the perpendicular to the production plane is the only allowed polarization direction due to parity conservation.

Once the polarization component perpendicular to the production plane has been shown to be consistent with zero, the problem reduces to a two-dimensional one, namely that of looking for polarization in the Λ production plane. The magnitude of the Λ polarization ($\sqrt{P_{A1}^2 + P_{A3}^2}$) is shown in Fig. 3 for several selection criteria in system "P". For clarity the figure is separated into two sets of cuts, one set in which large polarization signals are clearly seen (Fig. 3a) and the complementary data set (Fig. 3b). One feature immediately apparent is the similarity of the polarization magnitudes in the νp and $\bar{\nu} p$ data. It was found further that Λ hyperons produced in target fragmentation ($x_F < 0$) in the quasi-elastic (low Q^2 , low W) region are most highly polarized (selections 4, 6, 8 and 11). As can be seen from the selections 4 through 7 in Table 1, similar polarization results are achieved when replacing the Q^2 cut by a W cut. When a cut on the charged hadron multiplicity n_c is performed (selections 12 and 13) the polarization is consistent with being completely in events with the lowest n_c , namely $n_c = 0$ for $\bar{\nu} p$ and

$n_c=2$ for νp scattering. These observations suggest that perhaps specific exclusive channels are responsible for the observed polarization, for example $\bar{\nu} p \rightarrow \mu^+ \Lambda (\Sigma^0, \Sigma^0(1385))$ for the $\bar{\nu} p$ case, and $\nu p \rightarrow \mu^- K^+ \Sigma^+(1385)$ for the νp case. The channel $\bar{\nu} p \rightarrow \mu^+ \Lambda$ however can not be the cause of the Λ polarization observed in $\bar{\nu} p$ scattering due to the very limited number of events: only 5 events passed the 3C fit requirements for this reaction. Invariant mass plots showed that the only appreciable resonance in the νp data was the $\Sigma^+(1385)$ [12]. The quark content of the target remnant then implies that the $\Sigma^0(1385)$ should occur appreciably in $\bar{\nu} p$ interactions, and indeed another experiment confirms this [13]. Unfortunately the large γ conversion length in hydrogen made it impossible to investigate $\Sigma^0(1385)$ production in our $\bar{\nu} p$ data. In an attempt to determine whether the $\Sigma^+(1385)$ resonance was completely responsible for the polarization in the νp $Q^2 < 4\text{GeV}^2$ sample (selection 6), only events whose $\Lambda\pi^+$ invariant mass was within 50 MeV of the $\Sigma^+(1385)$ mass were analysed for polarization (selection 14). One sees that the polarization for such Λ particles is consistent with 75% and approximately 2.5σ from zero. However other sources of polarization can not be excluded since the polarization signal for Λ particles outside the $\Sigma^+(1385)$ mass band is still almost 2σ from zero (selection 15). The x_F dependence of the Λ polarization in the νp and $\bar{\nu} p$ $Q^2 < 4\text{GeV}^2$ samples is also presented (selections 10 and 11) and a trend towards higher polarization for larger x_F values is clearly seen.

To determine the direction of the polarization in the Λ production plane we have chosen the $x_F < 0$, $Q^2 < 4\text{GeV}^2$ sample (selection 8) due to its large polarization and adequate statistical precision. The qualitative results are however independent of the sample chosen. The polarization components of this sample in the Λ production plane are shown in Fig. 4 for systems "P" and "J", separately for νp and $\bar{\nu} p$ scattering. Also shown are the average values of the momentum vectors $\vec{J}$, $\vec{P}$ and $\vec{H}=\vec{J}+\vec{P}$ (the momentum of the remaining hadrons) in the Λ rest frame for the two coordinate systems. The averages are over all νp and $\bar{\nu} p$ events in this sample, since there was no appreciable difference between the two reactions. In Fig. 4 the vectors are normalized relative to each other such that the length of $\langle \vec{J} \rangle$ is unity. The Λ polarization in $\bar{\nu} p$ scattering is consistent with

being along the target proton direction while the direction of the Λ polarization in νp scattering is consistent with both the direction opposite to the current and the direction opposite to the remaining hadrons. It should be noted that the direction $-\hat{H}$ has special significance in the current-proton center of mass system. In this system $-\hat{H}$ is simply the flight direction of the Λ hyperon. Inspection of Fig. 4 also shows that the two systems "P" and "J" differ only, to a high degree of accuracy, by a rotation about the normal to the event plane. This is a consequence of the small average Λ laboratory momentum which means that the Λ rest frame does not differ greatly from the laboratory frame. This fact is the main reason why only two systems are shown in this analysis and why other systems present no additional information.

6) Theoretical Considerations

We have chosen a simple quark parton model (QPM) calculation due to Bigi [6] to compare with our results. Basically the model involves the interaction of a ν or $\bar{\nu}$ on a valence quark (see Fig. 1). Assuming V-A coupling and neglecting quark and lepton masses, the helicity state of the struck quark is negative in both interactions. Since the target is initially unpolarized, the removal of a quark with a specific helicity must leave the remaining diquark with a compensating polarization. One assumes that in the formation of the hyperon the spin configuration of the diquark is unchanged and that the acquired vacuum s quark carries both spin orientations with equal probability. The resulting three-quark state is then contracted with the standard SU(6) wavefunctions for the final hyperon to obtain the transition matrix elements for a specific hyperon spin orientation. The resulting polarization predictions are given in Table 2 for a few hyperonic final states of interest. The $\Sigma(1385)$ resonances ($\Sigma^+(1385)$ for νp and $\Sigma^0(1385)$ for $\bar{\nu} p$ scattering) are predicted to be highly polarized with similar magnitudes. The total Λ polarization in $\bar{\nu} p$ scattering may be smaller due to both the direct production of unpolarized Λ particles and the contribution of oppositely polarized Λ particles from Σ^0 production. The latter effect however is expected to be reduced due to the small (~ 0.3) Σ^0/Λ production ratio [13,14]. Qualitatively

the model accounts for the similarity of the polarization magnitudes observed in νp and $\bar{\nu} p$ scattering. It also gives an explanation for the large $\Sigma^*(1385)$ polarization (selection 14) seen in νp scattering and the observed x_s dependence (selections 10 and 11) since a valence quark must be struck to obtain the polarization predictions in Table 2.

The QPM can also make predictions for the polarization directions. In keeping with the spirit of the simple model we have assumed massless quarks, no primordial transverse momentum K_T of the quarks in the nucleon ($K_T=0$ in Fig. 1) and spin independence of the fragmentation process. With these assumptions the quarks are in pure helicity states and the problem becomes one-dimensional with the struck quark parallel to the current and antiparallel to the target proton directions. Neglecting, for the reason cited above, the Σ^0 contribution, the prediction is then that both νp and $\bar{\nu} p$ interactions produce Λ particles polarized in the direction of the target proton (see Table 2). This is in agreement with the $\bar{\nu} p$ but not the νp data. This discrepancy however is not surprising in view of the stringent and probably too simplistic assumptions made for the model predictions.

7) Summary

In summary, Λ hyperons produced in νp and $\bar{\nu} p$ interactions in BEBC have been analysed for polarization. All known sources that could have biased the results have been shown to be negligible relative to the statistical accuracy. The polarization results have been compared with predictions from a simple QPM and the following conclusions can be drawn;

- 1) Large and significant polarization is observed for Λ 's produced in the target fragmentation region of νp and $\bar{\nu} p$ interactions.
- 2) The polarization component perpendicular to the Λ -production plane is consistent with zero for both νp and $\bar{\nu} p$ scattering.
- 3) Significant Λ polarization is seen in the Λ -production plane; it is largest at small values of Q^2 or W , at large x_s , and for events with low charged multiplicity. The polarization magnitudes are similar in both interactions.
- 4) The direction of the Λ polarization in $\bar{\nu} p$ interactions is along

the direction of the target proton as seen in the Λ rest frame while the direction of the Λ polarization in νp interactions is consistent with the direction opposite to the weak current as seen in the Λ rest frame.

- 5) Large Λ polarization is seen inside the $\Sigma^*(1385)$ mass band for νp scattering, implying the creation of highly polarized intermediate $\Sigma^*(1385)$ resonances. The low conversion probability for photons prohibited a similar direct analysis for the Σ^0 and $\Sigma^0(1385)$ states in $\bar{\nu} p$ interactions. However the observed Λ polarization in $\bar{\nu} p$ has a similar magnitude and functional dependence as the Λ polarization in νp interactions, as would be expected if the $\Sigma^0(1385)$ were largely responsible. On the other hand, in νp interactions, other sources of polarized Λ particles can not be excluded since non-zero polarization exists also outside the $\Sigma^*(1385)$ mass band.
- 6) Most of the above observations agree qualitatively with the simple QPM predictions derived by Bigi [6].

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TABLE 1. The components of the Λ polarization for several data selection cuts in systems "P" and "J" for νp and $\bar{\nu} p$ scattering.

			NEUTRINO			ANTINEUTRINO		
#	SELECTION	AXIS	N(Λ)	SYS. "P"	SYS. "J"	N(Λ)	SYS. "P"	SYS. "J"
1	FULL SAMPLE	1 2 3	289	0.04 ± 0.13 0.01 ± 0.12 -0.25 ± 0.16	-0.10 ± 0.14 -0.02 ± 0.16 0.12 ± 0.15	267	0.25 ± 0.17 -0.06 ± 0.16 0.02 ± 0.16	-0.24 ± 0.17 -0.05 ± 0.16 -0.20 ± 0.17
2	$x_F < 0$	1 2 3	203	0.16 ± 0.17 -0.05 ± 0.19 -0.41 ± 0.19	-0.29 ± 0.18 -0.09 ± 0.19 0.19 ± 0.18	210	0.36 ± 0.18 0.01 ± 0.18 -0.06 ± 0.17	-0.38 ± 0.18 0.02 ± 0.18 -0.17 ± 0.18
3	$x_F > 0$	1 2 3	82	-0.34 ± 0.31 0.09 ± 0.28 0.10 ± 0.28	0.53 ± 0.30 0.08 ± 0.28 0.04 ± 0.29	57	-0.23 ± 0.37 -0.39 ± 0.32 0.39 ± 0.34	0.32 ± 0.35 -0.38 ± 0.34 -0.30 ± 0.36
4	$W < 4.5$ GeV	1 2 3	142	0.17 ± 0.22 0.16 ± 0.23 -0.52 ± 0.21	-0.42 ± 0.22 0.13 ± 0.23 0.33 ± 0.20	155	0.61 ± 0.21 -0.34 ± 0.21 -0.01 ± 0.20	-0.57 ± 0.21 -0.34 ± 0.20 -0.40 ± 0.21
5	$W > 4.5$ GeV	1 2 3	147	-0.04 ± 0.23 -0.19 ± 0.22 0.06 ± 0.20	0.22 ± 0.22 -0.20 ± 0.22 -0.10 ± 0.23	112	-0.10 ± 0.25 0.25 ± 0.24 0.20 ± 0.27	0.09 ± 0.25 0.26 ± 0.25 -0.01 ± 0.29
6	$Q^2 < 4$ GeV ²	1 2 3	138	0.26 ± 0.23 0.10 ± 0.22 -0.51 ± 0.22	-0.59 ± 0.23 0.09 ± 0.22 0.20 ± 0.22	156	0.52 ± 0.21 -0.01 ± 0.20 0.22 ± 0.23	-0.31 ± 0.20 0.01 ± 0.19 -0.60 ± 0.21
7	$Q^2 > 4$ GeV ²	1 2 3	151	-0.12 ± 0.19 -0.14 ± 0.22 0.01 ± 0.18	0.30 ± 0.21 -0.15 ± 0.23 0.04 ± 0.20	111	-0.16 ± 0.25 -0.16 ± 0.25 -0.16 ± 0.23	-0.07 ± 0.29 -0.18 ± 0.24 0.25 ± 0.26
8	$x_F < 0$ $Q^2 < 4$ GeV ²	1 2 3	99	0.34 ± 0.26 0.12 ± 0.25 -0.67 ± 0.25	-0.83 ± 0.26 0.10 ± 0.25 0.31 ± 0.25	115	0.76 ± 0.22 0.07 ± 0.24 0.11 ± 0.25	-0.52 ± 0.23 0.09 ± 0.24 -0.63 ± 0.25
9	$x_F < 0$ $Q^2 > 4$ GeV ²	1 2 3	104	0.05 ± 0.25 -0.27 ± 0.28 -0.16 ± 0.28	0.10 ± 0.24 -0.25 ± 0.27 0.09 ± 0.25	95	-0.21 ± 0.27 -0.16 ± 0.26 -0.18 ± 0.24	-0.11 ± 0.33 -0.16 ± 0.27 0.27 ± 0.27
10	$Q^2 < 4$ GeV ² $x_B < 0.15$	1 2 3	86	0.21 ± 0.28 0.07 ± 0.26 -0.30 ± 0.30	-0.38 ± 0.30 0.05 ± 0.27 0.02 ± 0.31	92	0.33 ± 0.28 0.11 ± 0.26 0.03 ± 0.27	-0.09 ± 0.25 0.13 ± 0.24 -0.37 ± 0.30
11	$Q^2 < 4$ GeV ² $x_B > 0.15$	1 2 3	52	0.42 ± 0.35 0.16 ± 0.36 -0.81 ± 0.31	-1.01 ± 0.36 0.14 ± 0.35 0.36 ± 0.32	64	0.76 ± 0.31 -0.19 ± 0.30 0.41 ± 0.33	-0.69 ± 0.31 -0.17 ± 0.30 -0.89 ± 0.29
12	$n_c = \begin{matrix} 2(\nu) \\ 0(\bar{\nu}) \end{matrix}$	1 2 3	124	0.06 ± 0.24 0.33 ± 0.23 -0.68 ± 0.22	-0.38 ± 0.24 0.30 ± 0.24 0.50 ± 0.22	64	0.80 ± 0.33 -0.33 ± 0.32 0.06 ± 0.30	-0.76 ± 0.31 -0.34 ± 0.31 -0.51 ± 0.30
13	$n_c \neq \begin{matrix} 2(\nu) \\ 0(\bar{\nu}) \end{matrix}$	1 2 3	165	0.06 ± 0.21 -0.24 ± 0.21 0.13 ± 0.20	0.14 ± 0.21 -0.24 ± 0.21 -0.15 ± 0.22	203	0.11 ± 0.19 0.00 ± 0.18 0.17 ± 0.20	-0.09 ± 0.22 0.01 ± 0.18 -0.12 ± 0.21
14	$Q^2 < 4$ GeV ² $\Delta < 50$ MeV	1 2 3	66	-0.01 ± 0.32 0.19 ± 0.30 -0.75 ± 0.29	-0.61 ± 0.32 0.19 ± 0.31 0.51 ± 0.31			
15	$Q^2 < 4$ GeV ² $\Delta > 50$ MeV	1 2 3	72	0.46 ± 0.30 0.05 ± 0.30 -0.32 ± 0.31	-0.54 ± 0.32 0.05 ± 0.30 -0.05 ± 0.29			

TABLE 2. Polarization of some hyperons in the target fragmentation region as predicted by the method of Bigi [6]. The numbers in parenthesis represent the Λ polarization after the decay of the parent state. Positive polarization corresponds to the direction of the target proton as seen in the Λ rest frame. A dash (-) means that the model makes no prediction for the polarization of that hyperon in the corresponding interaction.

Hyperon	νp scattering	$\bar{\nu} p$ scattering
Λ^0	-	0.00
Σ^0	- (-)	0.66 (-0.22)
$\Sigma^0(1385)$	- (-)	0.55 (0.55)
$\Sigma^+(1385)$	0.55 (0.55)	- (-)

FIGURE CAPTIONS

- Fig. 1 A QPM diagram showing the basic interaction on a valence quark. The spin of the struck quark before and after the collision is shown by the double arrows assuming massless quarks and leptons and conventional V-A theory. The flavor of the diquark remnant is indicated for both νp and $\bar{\nu} p$ interactions and the effect of primordial quark transverse momentum (K_T) on the struck quark trajectory and the diquark remnant is also shown.
- Fig. 2 The second component of the Λ polarization (along $\hat{J} \times \hat{P}$) in system "P" for νp (full points) and $\bar{\nu} p$ (open circles) scattering. See Table 1 for the definitions of the selection numbers.
- Fig. 3 The magnitude ($\sqrt{P_{\Lambda 1}^2 + P_{\Lambda 3}^2}$) of the Λ polarization in the production plane in system "P" for νp (full points) and $\bar{\nu} p$ (open circles) scattering. Fig. 3a is for the selections which exhibit the largest polarization values and 3b is for the complementary selections. See Table 1 for the definitions of the selection numbers.
- Fig. 4 The Λ polarization components in the production plane for the $x_F < 0$, $Q^2 < 4 \text{ GeV}^2$ sample for νp and $\bar{\nu} p$ scattering. The crosses give the errors on the two polarization components. The results are presented in systems a) "P" and b) "J". Also shown in each system are the vectors $\vec{J}$, $\vec{P}$ and $\vec{H} = \vec{J} + \vec{P}$ in the Λ rest frame averaged over all νp and $\bar{\nu} p$ events in the above sample and normalized such that the length of $\langle \vec{J} \rangle$ is unity.

Fig. 1

POLARIZATION PERPENDICULAR TO THE PRODUCTION PLANE

Fig. 2

POLARIZATION MAGNITUDE
IN THE PRODUCTION PLANE

Fig. 3

SELECTION NUMBER

Fig. 4