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ABSTRACT

Data are presented on charged current inclusive strange particle production in 10-200 GeV/c νp interactions in the Fermilab 15-Ft. bubble chamber. Final states with V^o decay topologies are reported: K_s^o, Λ^o (Σ^o), $\bar{\Lambda}^o$ $(\bar{\Sigma}^o)$. Neutrino energy, charged multiplicity, Q^2, W, x and y distributions are shown. The corrected relative V^o production rate is 0.16 ± 0.03 per event. The first example of neutrino-induced anti-baryon $(\bar{\Lambda})$ production is observed. The 90% confidence upper limit on $\Delta S = -\Delta Q$ inclusive Λ production is 0.036 of all charged current νp interactions above 10 GeV/c.

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Strange particle production by neutrinos is expected to provide considerable information on the nature of the weak interaction. Indeed the raison d'etre of the GIM[1] charm hypothesis is to suppress adequately strangeness-changing weak neutral currents.

We present results on V^o strange particle production in νp interactions from a 62,000 photograph exposure of the Fermilab 15-Ft. bubble chamber to a wide band neutrino beam. To select the charged current sample we take as muon the highest transverse momentum negative, which we require to lie on the opposite side of the neutrino direction from the vector sum of all remaining track momenta. The total background in the V^o sample is approximately 15% and arises from interactions of neutrons, K_L^o, $\bar{\nu}$, ν neutral currents, and charged current events in which the muon is misidentified. To estimate (to about ± 10%) the neutrino energy E_ν we take the total hadron direction as that of the visible hadrons projected onto the μ-ν plane and use transverse momentum balance. Further experimental details and discussions of the analysis procedures are given in Ref. 2.

Using this prescription, we restrict the final event sample to have visible longitudinal momentum > 7 GeV/c and E_ν > 10 GeV. The yields of V^o events in this sample of 543 charged current events are given in Table I. The corrected relative V^o production rate is 0.16 ± 0.03 per event. Contributions from non-V^o topologies (e.g., K^+, K^+K^-, $\Sigma^\pm K^+$) are not included in this determination. The observed rate appears to exceed earlier theoretical estimates.[3] In the low energy neutrino experiment of Barish et al.,[4] the rate $\sigma(\nu n \rightarrow \mu^- \Lambda K^+)/\sigma(\nu N \rightarrow \mu^- N + \text{pion}) = 0.04 \pm 0.03$.

The distributions in reconstructed neutrino energy and in charged particle multiplicity are given in Fig. 1(a) and (b) respectively. The smooth curves represent the total charged current distributions normalized to the V^o data.

The inclusive deep inelastic parameters of the V^o data are shown in Fig. 1(c) - (f). The W, Q^2, x and y distributions agree within statistics with the normalized total charged current data. We compare in Fig. 2 the W dependence of the relative V^o rates from neutrino-, electro[5]- and photoproduction.[6] Again, no significant differences are evident.

An example of antibaryon production by neutrinos has been observed. The event topology is five charged prongs with an associated unambiguous $\bar{\Lambda}$ as well as an associated single prong recoil. Two γ's are associated with the single prong recoil. The visible longitudinal momentum is 19.1 GeV/c so that production by a hadron is improbable. (The relative event density

$\frac{dN}{dE}$ (hadrons)/$\frac{dN}{dE}$ (neutrinos) is $<$ 0.02 near 19 GeV/c). The probability of production by an anti-neutrino is two orders of magnitude lower than for a neutrino. Since the event satisfies the charged current reconstruction procedure, we assume it to be such but cannot rule out a neutral current interpretation.

Based on this single event, the relative rate $N_{\bar{\Lambda}}/N_{\nu}$(charged current) $\approx$ 0.003. Other parameters of the event are E_{ν} = 24.3 GeV, Q^2 = 12.6 $(GeV/c)^2$. W = 5.6 GeV/c^2, x = 0.30 and y = 0.94.

Finally, we use the 17 Λ^o and 3 $\Lambda^o K_s^o$ events observed to set an upper limit on $\Delta S = -\Delta Q$ inclusive Λ^o production, an example of which has been reported by Cazzoli et al.[7] We take N_Λ (observed) $= N_\Lambda + N_{\Lambda K_s^o}$ where $N_\Lambda = N_\Lambda(\Delta S = -\Delta Q) + N_{\Lambda[\bar{K}]}$. Here $N_{\Lambda[\bar{K}]}$ is the number of ΛK^+ events plus the number of ΛK^o events with undetected K^o decays. If we assume the rates for $\nu p \rightarrow \mu^- \Lambda K^o X^{++}$ and $\nu p \rightarrow \mu^- \Lambda K^+ X^+$ are equal (the result is insensitive to this ratio) then $N_\Lambda(\Delta S = -\Delta Q) = N_\Lambda$ (17 events) $- 5.4 N_{\Lambda K_s^o}$ (5.4 x 3 events). The 90% confidence upper limit on $N_\Lambda(\Delta S = -\Delta Q)/N_{total}$ (charged current) is 3.6% for E_ν above 10 GeV. The final number includes all corrections for undetected Λ and K^o decays.

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Table I. Yields of Events with V^o Decays

V^o Decay	No. Events Observed With Visible V^o Decays	Inclusive No. Events Corrected*	No. Events Corrected*†
K_s^o	16	61.2 ± 14.0	43.8 ± 11.0
$\Lambda^o(\Sigma^o)$	17**	36.0 ± 8.0	18.6 ± 4.5
$K_s^o\Lambda^o(\Sigma^o)$	3	-	17.4 ± 10.0‡
$\overline{\Lambda^o}$ $(\overline{\Sigma^o})$	1	1.6	1.6
$3V^o$	1	-	7
TOTAL	38	-	88.4 ± 17.0

*We assume the number of K_s^o and K_L^o decays are equal and correct for invisible decays, finite chamber size and $1V^o$ - $2V^o$ mixing for invisible decays. No $K_s^oK_s^o$ correction has been applied.

†This means, for example, the corrected number of events with K^o and no Λ(detected or undetected).

‡This channel has contributions from both of the above listed channels

**Including one $\Sigma^o \to \Lambda\gamma$ decay with both Λ and γ visible.

FIGURE CAPTIONS

Fig. 1: Inclusive distributions for charged current events with V^o decays: (a) reconstructed neutrino energy, (b) charged multiplicity, (c) W, (d) Q^2, (e) x, (f) y.

Fig. 2: Comparison of V^o decay yields versus W for neutrino-, electro- and photoproduction data.