We have analyzed the single π^o production channels in detail. Protons from NC and CC candidates were studied and the energy and angular correlations of the two samples found to be similar. We have obtained a value of R.

$$R= \frac{\sigma(\nu_\mu + n \to \nu_\mu + n + \pi^o) + \sigma(\nu_\mu + p \to \nu_\mu + p + \pi^o)}{2\sigma(\nu_\mu + n \to \mu^- + p + \pi^o)}$$

After low energy and wide angle muon corrections we have 14 neutral current candidates and 66 charge current events in these channels. Using these numbers, the result is:

$$R = \frac{14}{66 \times (1.6)} = 14 \pm 7\%$$

The factor 1.6 is due to nuclear breakup correction. The error includes 3.4% due to statistics, 2% due to low energy and wide angle muon uncertainty and 1.7% due to the efficiency for detecting the neutron final state.

OBSERVATION OF SINGLE PION PRODUCTION IN NEUTRINO-LIKE INTERACTIONS WITHOUT A CHARGED LEPTON

CERN

Presented by A Rousset

Results of the 1967 CERN bubble chamber experiment have been published (1) and included an upper limit for single π^+ production by a neutral current (2). The pictures were re-analysed to find events consistent with the reactions:

$\nu_\mu p \to \nu_\mu n \pi^+$ (1)

$\nu_\mu p \to \nu_\mu p \pi^o$ (2)

$\nu_\mu n \to \nu_\mu n \pi^o$ (3) (dirty)

$\nu_\mu n \to \nu_\mu p \pi^-$ (4)

$\nu_\mu p \to \mu^- p \pi^+$ (5)

where the final state protons and pions were positively identified.

The π^+ were identified as positive tracks with momenta below 0.7 GeV/c characterised by either its decay ($\pi^+ \to \mu^+ \to e^+$), or by an interaction where the range of the particle or its ionisation is not compatible with a proton of the same momentum. The π^o's were identified by one γ-ray converted into an electron pair in the liquid. The π^-'s were identified as negative interacting particles. The protons were identified by their range, if they stopped, or by the ionisation of the track.

A single π^+ event was eliminated because it was compatible with cosmic-ray induced photo-production. The other events are not correlated with cosmic rays.

The number of events found to be compatible with reactions (1-5) are given in Table 1. All events were divided between two classes:

(i) "clean" events, in which charge is conserved according to the reaction scheme, and

(ii) "dirty" events, in which an otherwise clean topology is accompanied only by slow stopping protons.

Table 1 - The Events

Reaction	Identified tracks	Events Clean	Events Dirty
(1) $\nu_\mu n \pi^+$	π^+	3 + 1	5
(2) $\nu_\mu p \pi^o$ (3) $\nu_\mu n \pi^o$	$p\gamma$	2	1
(4) $\nu_\mu p \pi^-$	$p\pi^-$	3	0
(5) $\mu^- p \pi^+$	π^+	50	17
	p	77	33
	π^+ and p	37	14

The reactions (1), (2), (3) and (4) cannot be kinematically constrained and the π^+, π^o or π^- could be produced by neutrons in the reactions:

$np \to nn\pi^+$ (6)

$np \to np\pi^o$ (7)

$nn \to nn\pi^o$ (8) (dirty)

$nn \to np\pi^-$ (9)

The neutron flux can be estimated by the reaction:

$np \to pp\pi^-$ (10)

A search was made for events compatible with this reaction. Only one such event has been found, and it also compatible with the reaction: $\bar{\nu}_\mu p \to \mu^+ p \pi^-$. By charge symmetry reactions (6) and (10) have equal cross sections and in this experiment the π^+ and π^- detection efficiencies are approximately equal. The hypothesis that the 9 π^+ events were produced by reaction (6) and only one event by reaction (10) may therefore be rejected as having a probability smaller than 10^{-2}.

At low neutron momenta (below 2.5 GeV/c) the cross section for reaction (9) is greater than six times that for reaction (6). Taking account of the relative number of effective proton and neutron targets in propane, the number of $nn\pi^+$ and $np\pi^-$ events should be in a ratio of less than 1/3. The 3 $\pi^- p$ events and the possible $pp\pi^-$ event are the only candidates for reaction (9) in which the π^- at least is positively identified. The hypothesis that the 9 π^+ and the 4 π^- events are produced by neutrons can therefore only be retained at a confidence level of less than 2 10^{-3}.

In conclusion the 9 π^+ events are incompatible with the background at a 10^{-3} level of probability and these events can be considered as further evidence for the existence of weak neutral currents.

The cross section for pion production by neutral currents may be compared to that of the charged current process (5). The comparison is done using the events compatible with the $\mu^- p \pi^+$ topology, clean or dirty, applying the same identification criteria as for the π^+ events.

$$R_+ = \frac{\sigma(\nu p \to \nu n\pi^+)}{\sigma(\nu p \to \mu^- p\pi^+)} = \frac{8}{67} = 0.12 \pm 0.04$$

Using only the 3 measured clean events, the ratio is

$$R_+ = \frac{\sigma(\nu p \to \nu n\pi^+)}{\sigma(\nu p \to \mu^- p\pi^+)} = \frac{3}{50} = 0.06 \quad 0.04$$

In the pγ events the background contribution is estimated to be approximately one event. Therefore the 3 pγ candidates cannot be taken as a significant signal for neutral current interactions, but an upper limit for the processes (2) and (3) can be given:

$$R_o = \frac{\sigma(\nu p \to \nu p\pi^o) + 1/3\ \sigma(\nu n \to \nu n\pi^o)}{\sigma(\nu p \to \mu^- p\pi^+)} \leqslant \frac{3}{110 \times 0.4} =$$

0.07 ± 0.05

The factor 1/3 takes into account the relative number of neutrons and protons in the propane and the probability for an interaction to appear as dirty.

In the case of the 3 $p\pi^-$ events the contribution of the neutron background can be large, and the following upper limit can be given:

$$R_- = \frac{\sigma(\nu n \to \nu p\pi^-)}{\sigma(\nu p \to \mu^- p\pi^+)} \leqslant \frac{3}{51} = 0.06 \pm 0.04$$

References

1 I. Budagov et al., Phys. Letters, 29B, 524 (1969)

2 D. C. Cundy et al., Phys. Letters, 31B, 478 (1970).