CHARACTERISTICS OF SLOW PARTICLES EMITTED IN THE CHARGED CURRENT INTERACTIONS OF NEUTRINOS WITH EMULSION NUCLEI

E-531 Collaboration

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ABSTRACT

Multiplicity,angular and energy distributions of secondary particles, produced in the charged current inelastic interactions of high energy neutrinos with emulsion nuclei,were investigated.

1. Introduction.

In the charged current neutrino induced reactions on nuclei, a negative muon is emitted and a d-quark in a nuclear nucleon absorbing a W^+ boson, changes into a u-quark or a c- quark . This quark propagates inside the nucleus either singly or after immediate recombination into a meson, forming a leading particle system (LPS). The LPS may interact further with a nucleon inside the target nucleus with an effective cross section σ_0'. The value of σ_0' may depend on whether the LPS is a c-quark, u-quark, charmed meson or non-charmed meson . In each of these cases, the value of σ_0' may be reflected in grey track particle multiplicity distribution and its mean value observed in the final state. The aim of this paper is to test whether there is a difference in σ_0' for "charm" and "non-charm" events. Also, the study of the general characteristics of neutrino - emulsion charged current interactions . These characteristics are compared to the corresponding ones from proton - emulsion (P-Em) collisions.

2. Experiment.

The charged current interactions of neutrinos with emulsion nuclei were picked up from those observed in a hybrid emulsion spectrometer which was used in the Fermilab experiment E-531 to study charm particle lifetimes /1/ and their production cross sections /2/. The details of the performances of the apparatus and exposures were presented in /3/.

For the present study, the following selection criteria have been applied : (i) the event must be at least 20 mm apart from the stack edges. (ii) The event should include identified negative muon. The 260 events were selected, out of them 192 events with $N_h \geqslant 1$. These data were compared with events in which charmed particles were produced and a negative muon was identified without applying the geometrical cut mentioned in the criterion (i).These two sets are compared to each other and to proton - emulsion data /4/.

3. Multiplicities of Secondary Particles.

The table presents the average multiplicities of s,h,g and b particles emitted in "non-charm" and "charm" ν-Em charged current inelastic interactions. These values are compared to the corresponding ones from P - Em collisions at 22.5 GeV/4/.

Average multiplicity → / Class of events ↓	$\langle n_s \rangle$ (* without μ^-)	$\langle n_h \rangle$	$\langle n_g \rangle$	$\langle n_b \rangle$
"non-charm"	5.52±.15 * 4.52±.15	3.99±.30	1.35±.13	2.64±.25
"charm"	4.60±.26 * 3.60±.26	3.60±.60	1.23±.22	2.37±.37
P - Em at 22.5 GeV	5.61±.01	8.60±.25	3.38±.14	5.22±.29

The table shows that $\langle n_s \rangle$ for "charm" events is less than the corresponding one for "non charm" events by 0.85±.30 Such a difference could be explained by the copious D^0 meson production and generally by the fact that charmed particles are heavy ones which are usually produced with a relatively high momentum. The similarity of $\langle N_h \rangle$, $\langle n_g \rangle$, $\langle n_b \rangle$, observed in the table, between "charm" and "non-charm" events, indicates that there is no difference between a leading charmed or non-charmed particle. The table shows that for P-Em these values are about 1.5 times the corresponding ones from the ν-Em events. This observation can be explained by the known fact that hadrons tend to interact as soon as they enter the hit nucleus and after the first collision, there is still a considerable nuclear matter for the leading particle to propagate through it. Neutrino can interact at any point inside the target nucleus. Thus, the degree of intranuclear cascading in case of hadrons is more than the neutrino one.

The ratio of n_g=0 events, in ν-Em interactions, was calculated roughly from simple considerations of the quark theory and emulsion composition. Neglecting the cascading effects, the calculated value 0.4 agrees with the experimental value 0.5±0.1 . This shows that the number of intranuclear cascading is very small in this case. The study of correlations between different multiplicities has shown that the excitation energy of the residual nucleus is independent on the number and nature of produced particles (pions or charm particles) i.e. these produced particles do not transfer any significant energy to the target nucleus.

4. Angular and energy distributions.

It is a remarkable feature that grey track particles from "charm" and "non-charm" events have the same angular distribution of the form $\frac{1}{N_{tot}} \frac{dn}{d\cos\theta_g} \simeq \exp(0.83\pm0.13)\cos\theta_g$ which agrees with the corresponding one in hadron - nucleus collisions $\frac{1}{N_{tot}} \frac{dn}{d\cos\theta_g} \simeq \exp(0.96)\cos\theta_g$

The forward peaked behaviour and the increase in the value of F/B ratio with the increase in particle track range support the assumption that grey track particles are knock on recoils. The energy distribution of grey track particles, assumed to be protons, from "non-charm" events has the form $N(E)\,dE \simeq E^{-(1.15 \pm 0.18)}\,dE$.

5. Conclusions.

The measured n_g- multiplicity is consistent with simple quark counting and the number of intranuclear cascading in the present interactions is very small, so the theoretically expected difference in the cross section of a leading charm or non-charm particle has not been observed. The angular distribution of grey track particles has the form

$$\frac{1}{N_{tot}}\frac{dn}{d\cos\theta_g} \simeq \exp(0.83 \pm 0.13)\cos\theta_g$$

and their energy distribution is of the form

$$N(E)\,dE \simeq E^{-(1.15 \pm 0.18)}\,dE$$

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7. References.

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