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Measurement of the Scaling X and Y Distributions of Neutral and Charged Current ν_μ Interactions

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presented by P. Igo-Kemenes

*On leave from Heidelberg University, Heidelberg, F.R. Germany

MEASUREMENT OF THE SCALING X AND Y DISTRIBUTIONS OF NEUTRAL AND CHARGED CURRENT ν_μ INTERACTIONS*)

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We report on a joint study of the neutral and charged current reactions

$$\text{NC:}\quad \nu_\mu + \text{Ne} \rightarrow h + \nu_\mu$$
$$\text{CC:}\quad \nu_\mu + \text{Ne} \quad h + \mu^-$$

with the aim to obtain distributions in the scaling variables x and y. The experiment was performed at the FNAL narrow band neutrino beam (neutrino energies up to 240 GeV; mean energy: 60 GeV) and used the 15-foot bubble chamber filled with a heavy neon-hydrogen mix (59 atomic percent of neon) to detect neutrino interactions.

The narrow band beam allows one to determine the four-momentum of the incoming neutrino from the radial position of the interaction vertex [1]. The bubble chamber, on the other hand, permits one to detect the detailed composition of the final state hadronic system, h, and to reconstruct its four-momentum. From these the four-momentum of the *outgoing* lepton can be reconstructed on an event-by-event basis. The quality of the lepton reconstruction can be studied on charged current events for which the outgoing lepton, the μ^-, is detected.

The data sample consists of 950 ν_μ interaction candidates within a reduced fiducial volume which was chosen to insure a good containment of the hadronic shower and to improve the event reconstruction. The visible hadronic energy had to be increased by 15% on the average [2] to account for the undetected neutral particles.

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Neutral and charged current candidates were separated by the absence or presence of a μ^- which was designated to be the negatively charged particle with the highest momentum, leaving the bubble chamber without a hadronic interaction [3]. In this way, the sample was separated into 220 NC and 730 CC candidates. One had to correct for the "crosstalk" between the two samples due to a) CC events with a stopping μ^- ($\approx$ 0.5% of the CC sample) and b) NC events with a fake "μ^-" ($\approx$ 10% of the CC sample) that is: a π^- leaving the bubble chamber without interacting. The exact probability for this to occur was determined by three independent methods which gave consistent results. One of the methods used the observed NC candidates, the known geometry of the bubble chamber and the measured interaction length of the liquid to determine, for each NC event, the probability to produce a fake μ^-. This method also permitted to obtain the x and y distributions of the fake CC events which were used to correct the raw scaling distributions.

The NC sample contained an important background induced by neutrons and other neutral hadrons produced upstream of the bubble chamber. This background peaks at low energy; for this reason the analysis was restricted to the domain $y > 0.1$. Part of the background events were eliminated because the presence of some activity on the bubble chamber frame, upstream of the interaction vertex, favoured the hypothesis of a neutral hadron rather than a neutrino interaction. The *residual* background, about 15% of the NC sample, was determined by analysing the longitudinal distribution [4] of the NC and CC candidates, of a sample of identified neutrons and of the NC candidates recognized as background. After these considerations and correcting also for wide band neutrino interactions (ν_μ, ν_e and $\bar{\nu}_\mu$) we obtained for the NC to CC cross-section ratio

$$R = \sigma_{NC}/\sigma_{CC} = 0.29 \pm 0.05 ,$$

in agreement with other measurements.

In an independent analysis of the same CC sample we obtained previously [5]

$$\sigma_{CC}/E_\nu = (0.62 \pm 0.05)10^{-38} \text{ cm}^2/\text{GeV}$$

which yields for the NC cross-section slope:

$$\sigma_{NC}/E_\nu = (0.18 \pm 0.03)10^{-38} \text{ cm}^2/\text{GeV} .$$

To obtain the scaling distributions we analysed the NC and CC candidates with identical methods and selection criteria. The resolution in x and y was studied on the CC event sample by comparing the scaling variables calculated using the four-momenta of the *reconstructed* and the *measured* μ^-. We found: $\sigma_x \approx 0.1$ and $\sigma_y \approx 0.04$ with some asymmetric tails which are still to be understood.

Figure 1 shows the preliminary scaling distributions. A χ^2 fit to the CC y distribution gives $B = (Q-\bar{Q})/(Q+\bar{Q}) = 0.55 \pm 0.20$, and the NC y distribution is compatible with the Weinberg-Salam prediction for $\sin^2 \theta_W = 0.23$ and $B = 0.55$ (dotted lines in the figure). The NC and CC x distributions are, within the large statistical and systematic errors, compatible with each other.

Neutral current x distributions were previously reported by two groups: the authors of ref. [6] used an event-by-event reconstruction technique similar to the present analysis whereas the CHARM collaboration [7] applied a statistical unfolding method.

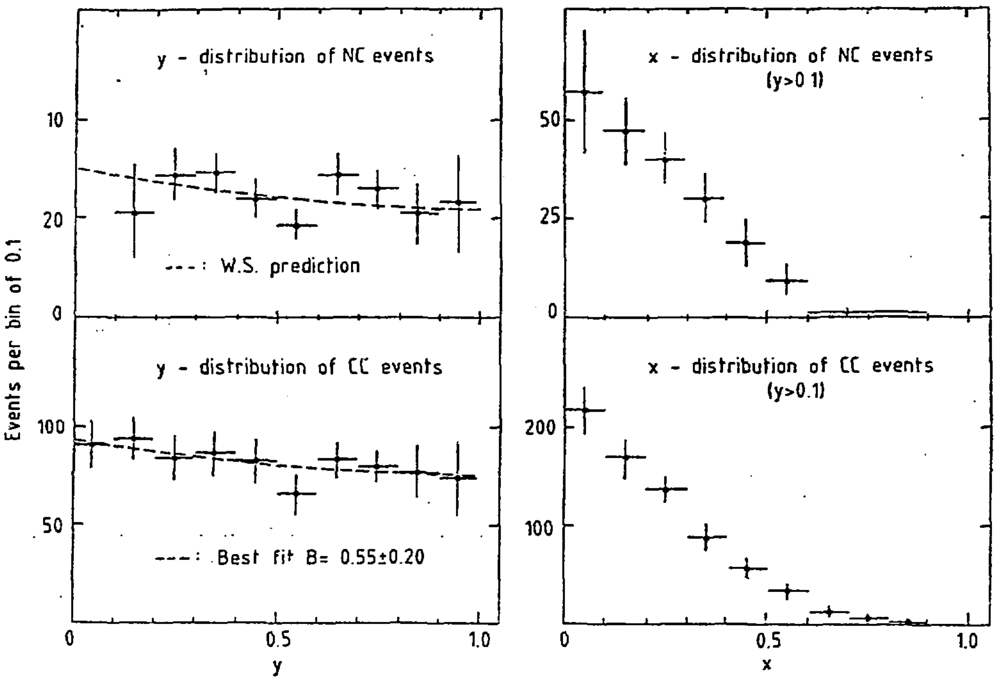

Fig. 1

REFERENCES

[1] For a given neutrino interaction the source (π^+ or K^+ decay) of the neutrino is unknown; thus, the energy obtained from the radial vertex position is ambiguous. In this experiment only 25% of the events were from K^+ decay neutrinos and more than half of them could be identified by the energy of the hadronic system which exceeded the neutrino energy for the π^+ decay hypothesis.

[2] The correction was parametrized, as a function of the visible hadronic energy, using the CC event sample and requiring total energy balance.

[3] The neon-hydrogen mix has a measured interaction length of 120 ± 15 cm for $\pi^\pm$; thus, hadrons typically interact within the bubble chamber whereas muons from CC events almost always leave.

[4] The genuine NC and CC events have the same, nearly uniform, longitudinal distribution modulated by the geometry of the fiducial volume, whereas neutrons and other neutral hadrons show an exponential attenuation characterized by the interaction length of the liquid.

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[6] C. Baltay et al., Phys. Rev. Lett. 44 (1980) 916.

[7] M. Jonker et al., CERN-EP/83-49, submitted to Physics Letters.

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