Preliminary data in the study of highly inelastic interactions between antineutrinos and nucleons at energies of 2–25 GeV in the SKAT chamber

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(Submitted 24 September 1979)
Pis'ma Zh. Eksp. Teor. Fiz. **30**, No. 9, 627–630 (5 November 1979)

Results are given of an analysis of an experiment on the highly inelastic interaction of an antineutrino with nucleons $\tilde{\nu}_\mu + N \to \mu^+ + X$. Distributions are obtained in terms of the scaling variables $x' = q^2/(2M\nu + M^2)$ and $y = \nu/E_{\tilde{\nu}}$. We determine the dependence of the mean square of the 4-momentum transfer on the energy: $\langle q^2 \rangle = (0.14 \pm 0.12) + (0.13 \pm 0.02)\, E_{\tilde{\nu}}$.

PACS numbers: 13.15. + g

The experiment was carried out in the SKAT bubble chamber[1] exposed to a broad-band antineutrino beam from the IHEP accelerator.[2] The chamber was filled with freon bromide CF_3Br which assures the positive detection of neutral particles and reliable muon identification. The total volume of the chamber available for photography is 6.5 m^3. The fiducial volume of the chamber was 1.7 m^3.

The data are based on an analysis of 55,000 photographs. All the events were scanned twice, and the scanning efficiency was 98%. The selection of candidates in the reaction for the highly inelastic interaction

$$\tilde{\nu}_\mu + N \to \mu^+ + X \tag{1}$$

was carried out according to the following criteria: the event vertex is located in the fiducial volume; there is a candidate for a μ^+-meson-positively-charged track in the event with maximum transverse momentum, which passes through the chamber without interacting; the sum of the longitudinal momenta of all the particles in a given interaction along the neutrino direction satisfies the condition $\Sigma P_x \geqslant 1$ GeV/c; the total visible energy in the event is $E_{\rm vis} \geqslant 2$ GeV; and the square of the momentum transmitted to the hadrons should not exceed the maximum allowable for this energy.

In all, 348 events were detected which satisfied these criteria. The background contribution (weak neutral current reactions: $\tilde{\nu}_\mu + N \to \tilde{\nu}_\mu + \ldots$ and neutron interactions) was determined by the study of events not having a muon candidate, and was 7%. In what follows, all the experimental distributions were corrected for the contribution from these processes.

To determine the antineutrino energy in each interaction, correction were introduced for lost neutrons, whose experimentally determined detection efficiency was 60%. Proceeding from the spectrum of the detected neutrons, the correction to the

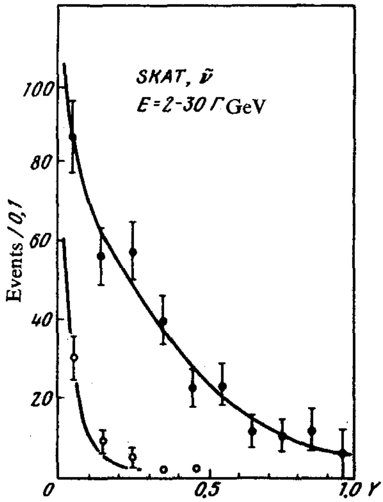

FIG. 1. Distribution of events in terms of $y = \nu/E_{\tilde{\nu}}$: ○—elastic events; ●—inelastic events. The dN/dy curves are calculated with structure functions from Ref. 3 and the expected spectrum $\tilde{\nu}_\mu$.

energy for each event as a function of the energy of the detected hadrons $E_{h,\text{vis}}$ was obtained in the form

$$\Delta E_h = 0{,}056 + 0{,}076\, E_{h,\text{vis}}. \tag{2}$$

The average energy resolution for this experiment taking into account nuclear excitation, scatter due to the Fermi motion of the nucleons in the nucleus, etc., was $\Delta E_{\tilde{\nu}}/E_{\tilde{\nu}} \approx 18\%$.

Figure 1 shows the distribution of events in terms of the variable $y = \nu/E_{\tilde{\nu}}$ ($\nu \equiv E_h$ is the corrected energy transmitted to the hadrons). In this figure open circles indicate the contribution of quasielastic events

$$\tilde{\nu} + p \to \mu^+ + n. \tag{3}$$

To isolate the process (3) we selected events in which there was a candidate for a μ^+ and not more than one neutron having a kinetic energy (E_{kin}) greater than 30 MeV. In addition, it was required that there be no protons with $E_{\text{kin}} > 30$ MeV in the event (the energy limit for the evaporation of nucleons).

The resulting curve in Fig. 1 takes into account the presence of the quasielastic background from process (3) and the highly inelastic scattering process (1), whose differential cross section $d^2\sigma/dx\,dy$ was calculated in the quark-parton model with structure functions from Ref. 3 with the substitution of the variable $x = q^2/2M\nu$ by $x' = q^2/(2M\nu + M^2)$, where q^2 is the square of the transmitted 4-momentum, and M is the mass of the nucleon. It is known that this substitution leads to better agreement between the experimental data obtained from eN- and μN-scattering and the conventional quark-parton model.

It is seen in Fig. 1 that the data in terms of the y-distribution agree with the predictions of the simple quark-parton model, and have the form

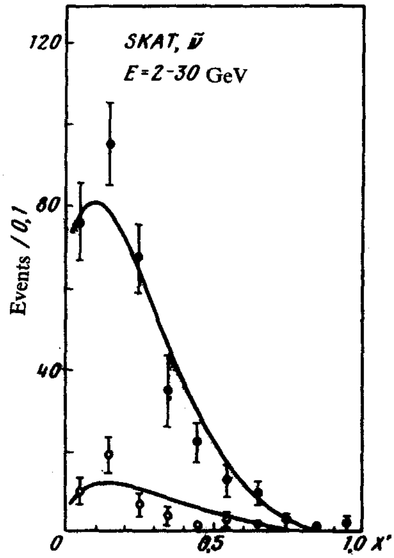

FIG. 2. Distribution of events in terms of the variables $x' = q^2/(2M\nu + M^2)$. Notation is the same as in Fig. 1.

$$\frac{d\sigma^{\tilde{\nu}}}{dy} \sim [(1-y)^2 + a],$$

where $a = \bar{Q}/Q = (1-B)/(1+B)$ and $B = (Q-\tilde{Q})/(Q+\tilde{Q})$ are the fractions of the antiquark momenta in the nucleon.

Figure 2 shows the distribution of events in terms of the variable x'. The lower points are the contribution of the quasielastic events (3). The expected distributions dN/dx' in processes (1) and (3) have been calculated within the framework of the assumptions given earlier.

The data presented here allow us to conclude that the parameterization of the structure functions obtained in Ref. 3 ($B \approx 0.86$) describe our data satisfactorily.

The scaling hypothesis predicts a linear behavior for $\langle q^2 \rangle$ as a function of neutrino energy: $\langle q^2 \rangle = 2m\langle xy \rangle E_{\tilde{\nu}}$.

Figure 3 shows the experimental dependence of $\langle q^2 \rangle$ on energy. The straight line corresponds to the two-parameter linear fit

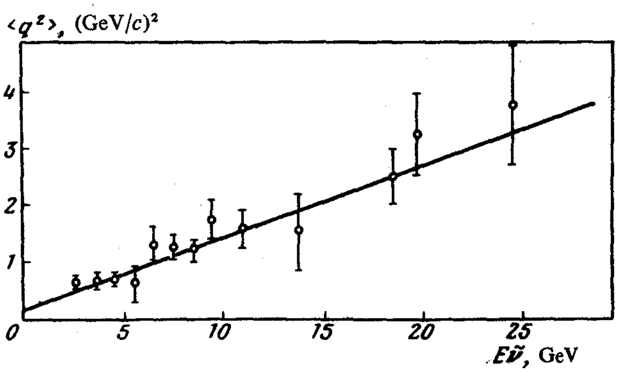

FIG. 3. Dependence of the mean q^2 on antineutrino energy. The straight line is the result of a two-parameter fit to the data.
(Gev/c)^2 Events GeV

$$< q^2 > = (0{,}14 \pm 0{,}12) + (0{,}13 \pm 0{,}02)E_{\tilde{\nu}}.$$

Within the limits of the errors this result agrees with similar data obtained for the Gargamel's chamber at energies of 2–10 GeV[4]

$$< q^2 > = (0{,}11 \pm 0{,}08) + (0{,}14 \pm 0{,}03)E_{\tilde{\nu}}.$$

and with data obtained for the IHEP-ITEF calorimeter at $\langle E_{\bar{\nu}} \rangle = 9.2$ GeV[5]

$$< q^2 > = (0\ 14 \pm 0\ 09)E_{\tilde{\nu}}.$$

These results lead to the conclusion that, within the limits of the available statistics in the energy range 2–25 GeV, qualitative agreement was observed between experimental data based on the highly-inelastic scattering of antineutrinos by nucleons and the predictions of a simple quark-parton model. This result agrees with our data[6] based on the study of highly-inelastic scattering of neutrinos in the energy range 2–30 GeV.

The authors thank L.D. Solov'ev, V.A. Yarbv, N.E. Tyurin, and S.P. Denisov for their continued interest and support of neutrino studies in the SKAT chamber, the SKAT chamber collectives, neutrino beam and to the photolaboratory and processing branch for assistance in conducting the experiment.

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