TOTAL ANTINEUTRINO-NUCLEON CHARGED CURRENT CROSS SECTION IN THE ENERGY RANGE 10–50 GeV

A.E. ASRATYAN, V.I. EFREMENKO, A.V. FEDOTOV, P.A. GORITCHEV, G.K. KLIGER, V.Z. KOLGANOV, S.P. KRUTCHININ, M.A. KUBANTSEV, I.V. MAKHLUEVA, V.I. SHEKELYAN, V.G. SHEVCHENKO
ITEP, Moscow, USSR

V.V. AMMOSOV, A.G. DENISOV, G.S. GAPIENKO, V.A. GAPIENKO, V.I. KLYUKHIN, V.I. KORESHEV, P.V. PITUKHIN, V.I. SIROTENKO, E.A. SLOBODIUK, Z.U. USUBOV, V.G. ZAETS
IHEP, Serpukhov, USSR

and

J.P. BERGE, D. BOGERT, R. HANFT, J.A. MALKO, F.A. NEZRICK and R. ORAVA
FNAL, Batavia, IL, USA

Received 18 August 1983

The total $\bar{\nu}_\mu$N charged current cross section in the energy interval 10–50 GeV is unfolded from 15′ bubble chamber antineutrino data. The method is to isolate the quasielastic events and determine their relative contribution to the overall charged current sample. The scale parameter is found to be (0.29 ± 0.03) × 10^{-38} cm^2 GeV^{-1}. Relevance of the method for neutrino oscillation studies is discussed.

Muon monitoring in the shielding is usually employed for the determination of neutrino flux in the total ν_μ ($\bar{\nu}_\mu$) cross section measurements. In this paper an alternative strategy is used which does not rely on muon monitoring. Instead, we first (i) isolate the quasielastic subsample within the overall charged current sample, and then (ii) determine the total charged current cross section from the relative contribution of the quasielastic channel in each energy interval. Such an approach is conceptually "oscillation free". On the other hand, the traditional technique is potentially open to neutrino-oscillation effects since neutrino flux is measured in the decay pipe rather than in the detector itself. Therefore with the combination of these two methods one can study possible variations of the ν_μ ($\bar{\nu}_\mu$) flux due to neutrino ocsillations $\nu_\mu \to \nu_X$.

Quasielastic antineutrino scattering on protons

$$\bar{\nu}_\mu p \to \mu^+ n$$

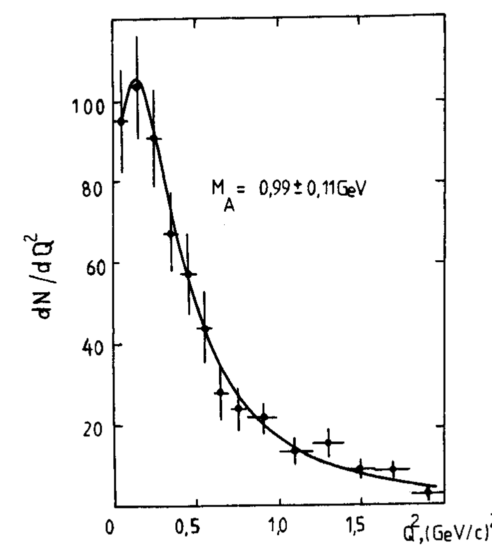

Fig. 1. Q^2 distribution for quasielastic events. The curve is computed with M_A = 0.99 taking into account the Pauli exclusion principle.

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Table 1

$E_{\bar\nu}$ (GeV)	$E_{\bar\nu}$ (GeV)	$N_{in} + N_{el}$	N_{el}	$\sigma_{tot} \times 10^{38}$ (cm^2)
8–12	9.8	1068.6 ± 57.7	162.1 ± 16.8	2.9 ± 0.5
12–16	13.9	1142.7 ± 50.9	133.7 ± 15.1	3.8 ± 0.6
16–20	17.9	957.8 ± 43.1	75.9 ± 11.3	5.6 ± 1.1
20–24	21.8	767.0 ± 36.9	52.0 ± 9.5	6.6 ± 1.4
24–32	28.3	1141.2 ± 44.1	67.1 ± 11.8	7.6 ± 1.6
32–40	35.3	640.0 ± 32.0	31.5 ± 7.7	9.0 ± 2.4
40–60	47.4	709.2 ± 33.3	22.7 ± 6.7	13.9 ± 4.4

was previously studied in GGM-PS bubble chamber experiment [1] at low energy (< 5 GeV). We study this process in a wide energy range 5–100 GeV. This, being of some interest in its own right, also serves as a consistency check: the agreement with earlier low-energy measurements verifies that we extract the quasielastic signal correctly. After this the quasielastic reaction becomes an important tool for total cross-section measurements since its cross section is known well.

The 15′ bubble chamber filled with a heavy neon–hydrogen mixture was exposed to FNAL wideband antineutrino beam (see ref. [2] for some details). In a special scan of 71 × 10^3 frames, 405 quasielastic events were observed (the single scan efficiency for one-prong events is 0.69 ± 0.03). Due to high gamma registration efficiency these events were reliably identified. From the Q^2 distribution (see fig. 1) the axial mass is found to be $M_A = 0.99 \pm 0.11$ GeV for $M_V = 0.84$ GeV. Within errors the M_A value is independent of energy and agrees well with previous low-energy measurements.

For isoscalar target, the total (σ_{tot}) and quasielastic (σ_{el}) cross sections are related through

$$\sigma_{tot} = \sigma_{el}(N_{el} + N_{in})/2N_{el},$$

where N_{el} and N_{in} stand for the numbers of quasielastic and inelastic events, respectively. We take $\sigma_{el} = (0.89 \pm 0.09) \times 10^{-38}$ cm^2 which corresponds to our M_A value. The energy distribution of inelastic events was corrected for Fermi motion, experimental cuts and energy resolution.

The results of our analysis are summarised in table 1. In fig. 2 the ratio $\sigma_{tot}/E_{\bar\nu}$ as a function of energy is compared with data from previous measurements [3–8]. Our data indicate no energy dependence for the slope parameter $\alpha = \sigma_{tot}/E_{\bar\nu}$. The one-parameter fit yields

$$\alpha = (0.29 \pm 0.03) \times 10^{-38}\ \mathrm{cm^2\ GeV^{-1}}.$$

Within errors our results agree well with those of previous measurements os that no significant oscillation effects are seen. In particular, comparison with GGM-SPS [4] (see fig. 2) shows that in the latter experiment no more than 20% of the initial $\bar\nu_\mu$ flux "oscillates away" in the energy range 15–25 GeV

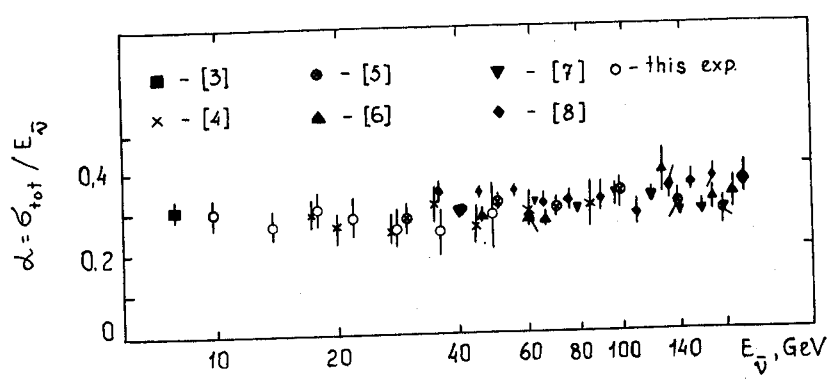

Fig. 2. Antineutrino interaction cross section divided by the mean energy value, calculated for isoscalar target.