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# Analysis of Charged-Current Neutrino-Nucleus Cross Section

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**Abstract.** A study of the cross section for chaged-current quasielastic (CCQE) scattering on nuclei has been performed using a description of nuclear dynamics based on the Relativistic Fermi Gas model (RFG). The role played by different parametrizations for the weak nucleon form factors is analyzed taking into account the relevance of the axial mass value. The results obtained are compared with the recent data for neutrinos measured by the MiniBooNE Collaboration.

**Keywords:** neutrino weak interaction, MiniBooNE, nuclear reactions, cross section, axial mass
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Recent interest in neutrino interactions in the few GeV energy region comes from neutrino oscillation experiments and from the study of the weak structure of nucleons. The goal of this work is to investigate at depth elastic and quasielastic neutrino scattering processes in this energy region and to analyze new cross section measurements performed by the MiniBooNE Collaboration at Fermilab. The difficulty to obtain high quality data is due to the poor knowledge of neutrino fluxes and to the fact that all recent cross section measurements have been taken for nuclear targets so our analysis depends on the uncertainties associated to nuclear models. We assume the Born approximation and focus on inclusive charged-current (CC) neutrino scattering on $^{12}$C, which is the nuclear target used in MiniBooNE.

We consider the Relativistic Fermi Gas model (RFG) as a description of the nuclear dynamics and the Impulse Approximation where the neutrino interacts with a single bound nucleon. This is consistent with the quasielastic (QE) regime. In spite of its simplicity, the RFG model allows us a fully relativistic description of neutrino-nucleus scattering without further approximations. In order to describe the weak nucleon form factors, we have compared Galster parametrization with the new GKeX one based on VMD models, concluding that the latter provides a better agreement with data, as shown in [1]. In particular, we study inclusive CCQE neutrino scattering on $^{12}$C: $\nu_\mu + A \rightarrow \mu^- + p + (A-1)$ , where the cross section is given in terms of separate nuclear response functions, $R_K$, and kinematical factors, $\hat{V}_K$ (see [2] for details):

$$\frac{d\sigma}{d\Omega} = \sigma_0 \mathscr{F}_\chi^2 \quad ; \quad \mathscr{F}_\chi^2 = [\hat{V}_{CC}R_{CC} + 2\hat{V}_{CL}R_{CL} + \hat{V}_{LL}R_{LL} + \hat{V}_T R_T] + \chi[2\hat{V}_{T'}R_{T'}] \ . \quad (1)$$

With these ingredients and taking into account the $\nu_\mu$ flux at MiniBoone, we obtain the CCQE flux-integrated differential cross section and the flux unfolded CCQE cross section, which are presented in Fig. 1. We compare with MiniBooNE data by using the standard axial mass ($M_A = 1.03$ GeV) and a larger value, $M_A = 1.35$ GeV [3]. These

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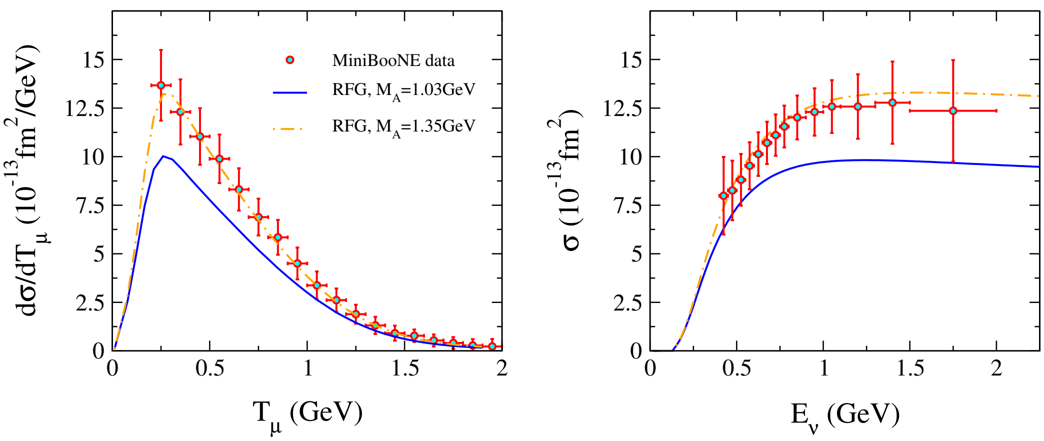


**FIGURE 1.** Comparison between cross section MiniBooNE's data [4] and RFG model using two different axial mass values. Left panel: Flux-averaged croos section displayed versus the muon kinetic energy. Right panel: total CCQE cross section per neutron versus the neutrino energy.

results are consistent with previous studies considering more sophisticated models [4]. Based on the Impulse Approximation, the use of a larger axial mass is shown to improve the comparison between theoretical models and MiniBooNE data.

To conclude, it is essential to point out that the improvement in the comparison between theory and data when using a larger axial mass should be taken as an indication of incompleteness of the theoretical description of the MiniBooNE data. Recent studies [4] have shown that *2p-2h MEC contributions* lead to a significant enhancement of the cross section. Additional effects related to correlations, nucleonic resonances and deep inelastic scattering are surely needed to explain experimental data at larger energies (>10 GeV) [5]. Thus, our goal in the future is to include these effects within the framework of more sophisticated models. All this together with new expected and more precise experimental data open new perspectives of paramount importance for neutrino-oscillation experiments. In the coming future, we plan to pursue along this research line.

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